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Index to Advertisers and Classified Index Following Reading Matter.

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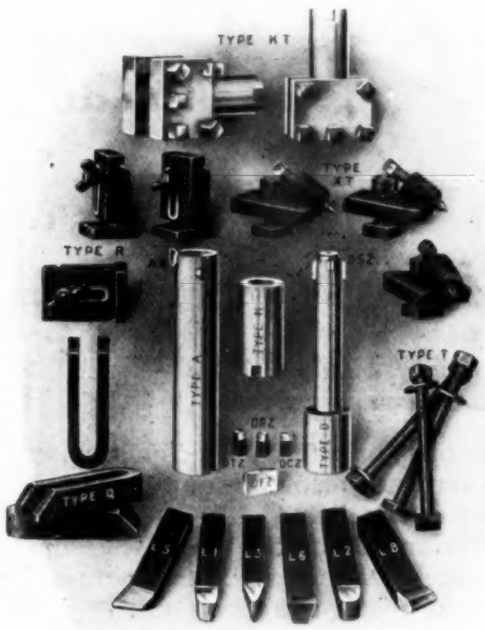

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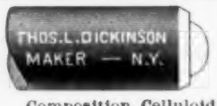

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The Most Powerful of All Steam Engines

Features Involved in the Design and Construction of a Monster Reversible Rolling-mill Engine at the Carnegie Steel Works

BY JAMES TRIBE

The accompanying illustrations show a horizontal twin-tandem compound reversing blooming-mill engine recently built by the Allis-Chalmers Company and installed at the Carnegie Steel Company's South Sharon (Penn.) works.

This engine is designed to operate condensing with 150 pounds boiler pressure, and to run at a maximum speed of 200 revolutions per minute, under which conditions, being equipped with a valve-gear capable of cutting off as late as three-fourths stroke, it will develop 25,000 horse-power, making it the most powerful rolling-mill engine in the world.

The two high-pressure cylinders are each 42x54 inches and the two low-pressure 70x54 inches. They are of the balanced piston-valve type, having one valve for each of the high-pressure cylinders and two for each of the low-pressure. Each end of each cylinder is fitted with a spring and relief valve, set slightly above boiler pressure, to relieve the cylinder from condensation water.

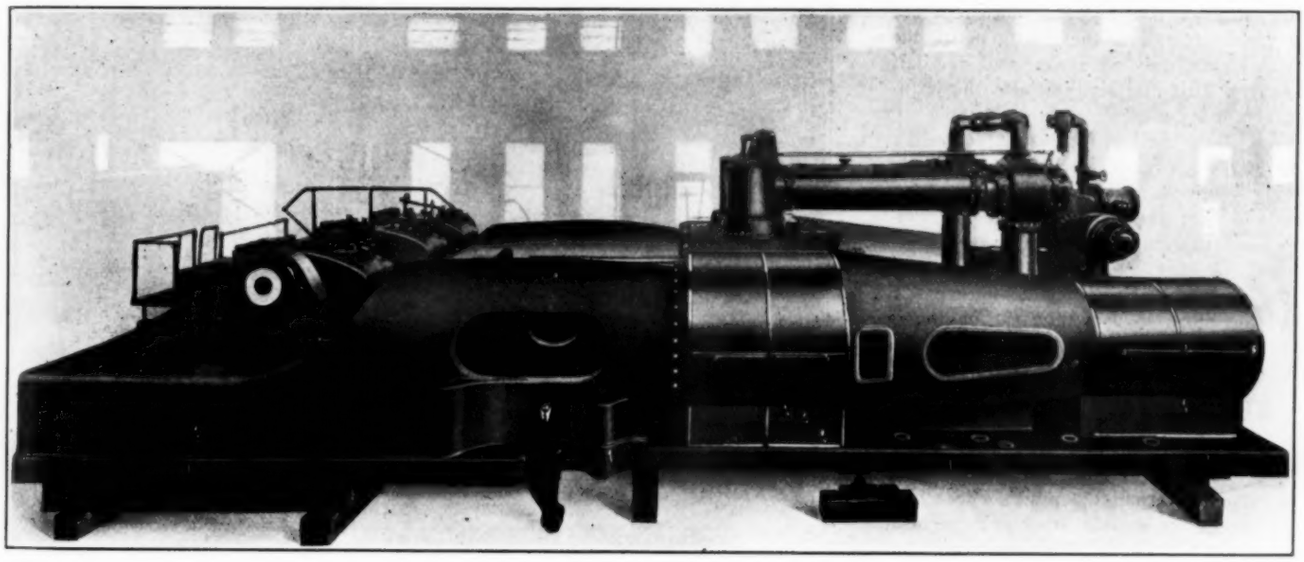


FIG. 1. 25,000 HORSE-POWER ALLIS-CHALMERS ROLLING-MILL ENGINE

This engine, without its foundation, measures 56 feet long, 26 feet wide and 18 feet high and weighs 550 tons.

The tremendous strain and shocks caused by the suddenness with which the load changes from minimum to maximum, the almost instantaneous stalling of the engine as the rolls bite the ingot, the sharp reversing of the machine from one direction of rotation to the opposite, and the high speed acquired at the end of the pass and just preceding the reversal, all subject the reversing blooming-mill engine to a more severe test than perhaps any other class of machinery of such dimensions.

In order to provide for withstanding these shocks without liability to delay or disablement by distortion, heating or breakdown, and at the same time to maintain in good order, for indefinite periods of time, an engine so delicate as to respond instantly and with precision to the will of the operating engineer, it was of the highest importance that every detail and the lines of the engine in general should receive that careful and painstaking study, as well as accuracy in shop treatment, which only past experience, scientific methods, good workmanship and modern machine-shop equipment can afford.

The various problems of the most vital importance which engaged the attention of the builders during the design and construction of this engine, were in part as follows:

Stability and Rigidity of all Stationary Parts

To accomplish this in the most thorough and substantial manner, the main frame and slide for each side was cast in one piece, forming two of the most massive castings ever used in a steam engine. One of the castings weighs 115 tons, the other 105 tons.

Between these two huge castings is a distance piece, also very heavy, accurately planed, and the parts firmly drawn together by forged steel links, so lending strength and firmness to the three main bearings, which, when once brought into alinement with the roll train, makes it absolutely impossible to distort or change the setting. Secured to these frame pieces and extending back under the entire engine, are heavily ribbed foundation plates 12 inches deep, which are fitted to each other and also to the main frames by planed joints of the tongue-and-groove type, and securely tied together by forged steel links of unusually large dimensions.

This 350 tons of cast iron was laid upon a foundation built of 1700 cubic yards of solid concrete, then leveled and grouted and made fast by forty-two 3-inch bolts, extending downward 18 feet into the masonry. This mass of material forms the backbone of the engine and affords an unyielding anchorage far in excess of any strain to which the machine can possibly be subjected.

Expansion and Contraction

In those parts of a steam engine which are subjected to the influence of steam heat, alternate expansion and contraction are, of course, unavoidable; and while in certain parts of this engine rigid and unyielding qualities were provided, so also in other parts, as the four steam cylinders, the steam and receiver piping and other details in contact with them, it was considered equally important that provision should be made for the freedom of the

parts affected by these changing conditions. For this purpose grooves were planed in the foundation plates in accurate alinement with the engine center-lines, and corresponding tongues on each cylinder, so as to permit longitudinal expansion and contraction without undue strain or buckling. For the same reason, balanced expansion joints and carefully laid-out pipe lines were adopted.

Compounding

The economy gained by multiple expansion in a rolling-mill engine is very uncertain. For the compound engine to give its best results, it should be run under constant load and for long periods without stopping. But rolling-mill conditions, especially in the blooming mill, are exactly the opposite. In a reversing blooming mill in which the passes are very short, reducing the ingot to perhaps a 12x12-inch bloom, the disadvantages of reversing every few seconds are very apparent. Under such conditions the changes are sudden and severe, ranging from excessive overload even to stalling, to "all off" at the end of each pass, and all within a few seconds, and repeated in rapid succession, the treatment of one ingot lasting only about one and one-half minutes. This materially offsets the economy sought by compounding.

But if the mill can be made to reduce the ingot to, say, 4x4-inch billets, the heat being retained as the delays by stalling become less, the length of the pass increasing thereby and the load becoming more constant and for longer periods, then a decided gain may be anticipated, and the more so providing the engine is condensing and has a sufficiently high boiler pressure available.

Stresses

Another special point in this engine lies in the fact that the entire valve-gear is without overhanging pins. These pins are carried by double arms and are supported at both ends; thus, the stress being central, the fiber stress in bending is reduced to the minimum and the surface pressure is better distributed.

In an engine of this type the crank-pin is doubtless more severely abused than any other part. The most severe stress on the crank-pin occurs at that moment when the ingot enters the rolls. This shock, of course, may happen at any point of the stroke, and if it occurs at or near mid-stroke when the crank-pin is moving at its highest velocity, the sudden and sometimes unyielding resistance, often sufficient to bring the engine to rest in a moment of time, throws a stress on the pin which is liable to exceed even the maximum inertia effect at the end of the stroke.

Deflection

For the successful operation of such an engine, it is also highly important that the weight-carrying members, which are subject to deflection, should yield only in the smallest possible degree; this is especially important in the main shaft and the piston-rods. With this in view, the main shaft was made hollow and proportionately larger in diameter. For, even though there be no fly-wheel to cause deflection, the "on and off" nature of the work demands that perfect alinement be maintained in order to avoid all possibility of heating.

The low-pressure piston-rods were also made hollow, the hole extending from the main crosshead through the low-pressure piston to an intermediate crosshead located between the two cylinders. In this way the low-pressure piston, which is preferably of cast steel, to reduce reciprocating weight, is carried free of the cylinder, and the limited deflection of the rod prevents the liability of cutting by contact between the cast-steel piston and the walls of the cast-iron cylinders.

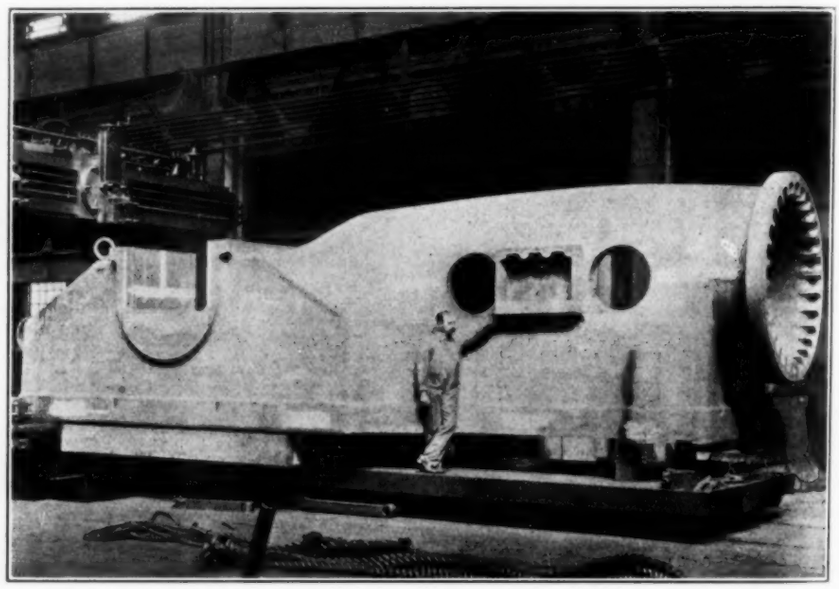


FIG. 2. A MAIN FRAME CASTING ON THE PLANER

The high-pressure piston has a solid rod and no tail-bearing. The reason for this is that the high speed contemplated, 200 revolutions per minute, forbids the additional reciprocating weight and the consequent additional inertia effects.

Inertia Effects

Under the head of "inertia effects" lies a problem of more than ordinary importance. Significance in this engine is multiplied on account of the pre-determined high speed, never before attempted in an engine of such magnitude under like conditions. Inflexible natural laws set the limits of engineering achievement and make it imperative that the danger point be approached very cautiously. Since, therefore, the problem was bounded by two limits, namely, the natural laws on the one hand, and on the other the high speed demanded by circumstances beyond the builders' control, there remained but one solution and that about as follows: In the first place, the weight of the reciprocating parts must be reduced to the minimum consistent with strength, and not a pound of metal used that could be dispensed with.

In the next place, all reciprocating parts must be made of the very best quality of material, so that the stress per square inch might be carried as high as necessary and yet remain within the safe limits of the strength of the material used. For instance, the best quality of open-hearth steel, perfectly sound and carefully machined, having an elastic limit of 36,000, and an ultimate strength of 70,000 pounds, may be depended upon to carry safely a load entailing a fiber stress as high as 9000 pounds per square inch.

In the third place, since the surface pressure per square inch on the crank-pins, due to the inertia of the reciprocating parts, approaches more nearly the danger point than that on any other part of the engine, ample surface should be provided. Experience has shown that this pressure may reach as high as 2500 pounds per square inch, with safety, providing the crank-pins are made of high-carbon steel and the babbitt in the connecting-rod boxes is of the best quality and properly supported against crushing.

It is a matter of easy calculation that in this engine the total inertia effect has a maximum value of 632,000 pounds, which, reduced to pressure per square inch in the crosshead pin becomes 2257 pounds.

Of course, while the engine is under steam, the cushioning in the steam cylinder assists in counteracting the inertia effect; but this must not be depended upon too much, for the reason that the highest speed occurs at the moment after the bloom has left the rolls, and, the steam being shut off at that instant, the cushioning is cut out at the very time the

gine needs it most. Therefore, sufficient pin surface was provided to sustain the whole inertia effect, irrespective of the advantage gained by cushioning during the more favorable periods.

Stalling Action

Being a reversing engine and, for obvious reasons, having no fly-wheel, the momentum of the rotating parts is comparatively nothing; therefore, the stalling effect at the moment of biting the ingot, and especially when at that position of the crank-pin least favorable to transmitting the necessary power, has always been a serious problem for the engine builders to solve. In this instance, however, five features have been included by which this stalling tendency has been reduced: First, the duplex feature of the machine, with cranks set at 90 degrees; second, the tandem type, insuring equal power on each crank, and the further advantage of having a high-pressure cylinder on each side; third, the long range cut-off, by which means a higher and more uniform pressure on the pistons may be had during the critical moments; fourth, the two pistons on each side, both subject to steam pressure and the larger subject to vacuum also; fifth, the throttle valve on each low-pressure cylinder, made to open and close a little in advance of that on the high-pressure cylinder, thus securing higher receiver pressure on the low-pressure piston to more quickly recover itself in case of stalling.

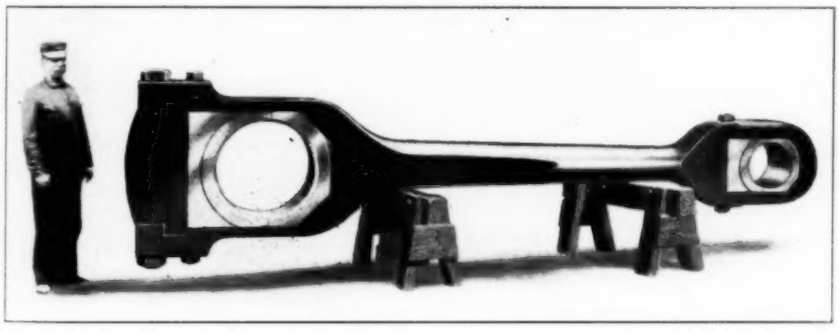


FIG. 3. ONE OF THE MAIN CONNECTING RODS

Power

The maximum capacity of this engine is 25,000 horse-power; not that this enormous power will be developed continuously, but rather that there may be a liberal surplus held in reserve for those brief moments when, due to the tremendous impact as the ingot enters the rolls, the tangential resistance at the rolls' surface is at its maximum; which surplus power or reserve energy will save that time which would otherwise be wasted while waiting for the engine to recover itself. In other words, this reserve energy is intended to do exactly what the energy stored in a fly-wheel would accomplish if other more serious conditions did not bar the use of that method of equalization.

Heretofore the ordinary blooming-mill engine has had too little surplus power, with the result that the operation of the mill has been delayed every time the engine has been stalled. Even though it be only for a few moments at a time, this amounts to considerable loss in the day's run. But the term "horse-power" does not convey to the mind the measure of effort necessary for the overcoming of the resistance at that moment immediately following the stalling action; for, inasmuch as that the engine is almost, if not quite, brought to rest at the instant of impact, the elements of time and space are practically eliminated for the time being, and the engine reduces itself to a simple force acting on the crank-pins; hence it becomes a question of the measure of the turning moment sufficient to overcome the tangential resistance on the rolls and the regaining of its former velocity in the shortest possible time.

The engine, as a whole, stands unique in rolling-mill practice and is a splendid example of skill and achievement.

Some Vicissitudes of the Job Shop

By J. G. Dornbirer

There was a young man in our town who had the notion that the machine industry was the most promising occupation (next to that of county commissioner) extant. After he graduated from the high school and discovered that there were a great many applications in ahead of his for the presidency and the various gubernatorial chairs, he decided to visit a friend of his in a large city pending an opportunity as undergraduate rivet heater in a boiler shop. He was notified one day to come at once; the opportunity had arrived.

Well, he was in this position about two weeks. One morning he strolled into the shop and had quite a long talk with the boss. He still had a few hundred dollars left out of a considerable sum left to him by a wealthy relative. With this he purchased from the boss an old 18-inch lathe and a 20-inch drill press. He got hold of a second-hand engine and boiler. He thought it must take lots of power to turn iron and steel, for the engine and boiler were a 25-horse-power outfit. After everything was set up he started to manipulate a machine shop.

His city friend, who was employed in a tool-building establishment persuaded him not to dirty his hands on job work, so he decided to build bench grinders. He telephoned down one day (in the early stages of the game) that the drill press which the boss sold him would not bore a hole over ½ inch diameter in soft iron in less than a day, requesting that we send a man up to see if everything was right. So the boss sent old Joe. After investigating the drills to see whether the grinding was done properly, Joe put one in the press to see how it acted on a piece of iron. He found that it was running backward.

This bright young man was called to the phone at this time, so Joe changed the belt from crossed to straight, bored three or four holes, put the belt back where he found it, and stood waiting when the man came out. Joe told him it was all right; the fault was not with the drill press, but elsewhere. He did not want to pose as an ignoramus, so he did not ask Joe how he did it, but went on talking about things in general. We never heard another complaint from this novice until about three months later when our apprentice (who, by the way, was a classmate of this alleged builder of machinery) stopped in one day to see him. Of course our whole shop knew what had been done, so our apprentice inquired how things were going and was informed that he had no trouble, barring a little squeaking of the drill. He had the drills ground to cut about as well running in either direction. The apprentice then reground his drills, changed the belt and showed him results. He was so astonished that he did not believe that iron was being bored until he got through several pieces to be sure nothing was wrong.

One day he sent over to have the boss come to figure on putting new flues in his boiler. The boss noticed a nice new shaper, and went over to examine it. Having learned a lesson on the drill he thought he might learn a little on the shaper. He informed the boss that his countershaft speed was what the builder had recommended, but he could get no tool to stand up. The shaper was started (it was a crank shaper); the stroke happened to be set long, and the ram came out as though it was trying to strike the man who set it up, then it returned slowly. Of course no tool would stand up; we had no high-speed steel in those days.

By this time this young man began to think it a good idea to learn something about the art. So the boss took him in to learn the trade; in the meantime he closed his shop. After he went through all the stunts, such as hunting left-hand monkey wrenches and being sent to a

booze garage for a pint of electric fluid to start the little generator (just on the same principle that you have to prime a pump) he finally made some headway.

Now to show that it does not always follow that because you can fool a fellow a few times that he is a "bonehead!" Neither does one man know it all. One day a drawing was sent in (I say a drawing because in those days we had men who called the crudest sketch a drawing, who talked in thousandths and worked both to the positive and negative side of sixteenths as their limits). This drawing came from a hardware dealer. An axle on a hay tedder was to be turned about one thousandth of an inch over 1¼ inches. Now he had written one thousandth like this, ".001." The sketch was handed to old Joe to do the job. He looked it over, scratched his head, looked over his glasses kind o' sheepishly to see if anyone was looking at him, then motioned for the apprentice to come over (it was the same one who ran the drill and shaper the wrong way). He said, "Say, Jack, what does this man mean by this?" pointing to the .001. Jack looked at it, then remarked that it was a left-handed one hundred, and that people who write left-handed always make figures that way. This seemed to satisfy Joe, but he still ventured another inquiry, "Why was this left-handed hundred put there?" The young man informed him that it was an expression used by agricultural-machinery builders, and usually stood for one-tenth. Joe completed the job accordingly and found the axle fitted perfectly.

Well! this apprentice learned fast and stayed four years, yet always keeping his aim in view. He then went to his shop and saw the many absurd things he did when he first started.

He might have been eminently successful but for one proclivity. The definition of the word business as he interpreted it was wrong. He defined it as follows: "Business is a method of getting into possession of material wealth without getting your material self into the possession of the material clutches of the law."

He now ordered the boss to put the flues in his boiler which were needed four years previous. The flues were put in at once, and he started to make bench grinders. The flues leaked; the flue sheet was very bad; it was almost impossible to keep them tight. He had no money to pay for the job, so the smallest leak was an excuse for standing off the boss another month. Every manufacturer of machinery has come in contact with this class of criminals. He tried to do business for about a year on other people's cash, but could not make it go. The boss bought his tools and we learned years later that he became a very successful stock promoter.

The Proper Way to Use Link-belt

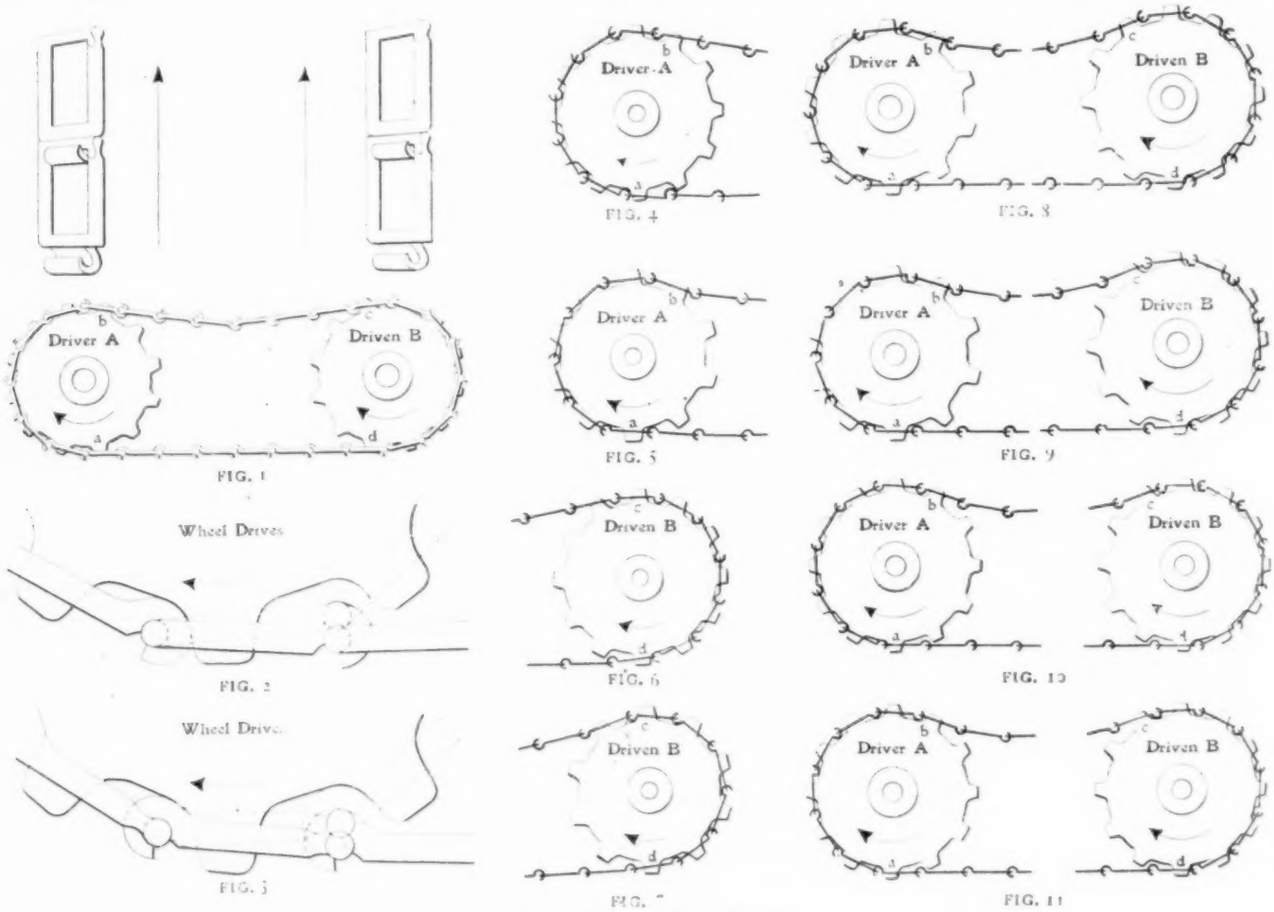
By Staunton B. Peck*

When considering the relative merits of different methods of running chain-drives, the drive should be considered as a whole, and the action noted at four points: *a*, entering point on the driver; *b*, releasing point on the driver; *c*, entering point on the driven; *d*, releasing point on the driven, as shown by *a b c d*, in Fig. 1.

In this discussion the action at a point is said to be good when all the articulation or bending takes place in the joint of the chain, Fig. 2. The action is said to be bad when, in bending, the link rubs on the sprocket, producing wear on the sprocket and outside or external wear on the hook, Fig. 3.

Another fact is also to be remembered: There is never more than one tooth in action at any one time. No matter how carefully the chain and sprocket may be made, as soon as the load comes on, there is a change caused by stretch and wear.

We can pre-determine which tooth shall be in action by making the pitch of the wheel either larger or smaller than the pitch of the chain. Thus, on the driver,



THE PROPER USE OF LINK BELTS

*Vice-president, Link-Belt Company, Chicago, Ill. From a copyrighted pamphlet of instruction.

Fig. 4, the wheel pitch being smaller than the chain pitch, the entering tooth does all the work. In Fig. 5 the conditions are reversed: the wheel pitch is the larger and the releasing tooth does the work. On the driven the same thing holds, except that here conditions are reversed.

When the wheel pitch is smaller than the chain pitch the releasing tooth does the work, Fig. 6, and when the wheel pitch is larger than the chain pitch the entering tooth does all the work, Fig. 7.

The Best Conditions

For the best work the pitch of the driver should be larger than the pitch of the chain (see Fig. 5), and the pitch of the driven should be smaller than that of the chain, as in Fig. 6. The releasing teeth *b* and *d* are, therefore, the working teeth, and the chain can seat at *a* and *c* quietly and take the load gradually as the wheel revolves.

Having considered the question of wheels, we will now regard the drive as a whole to determine whether the chain shall be run bar first or hook first.

In Fig. 8 we have the driver large, the driven small; hence *b* and *d* are the teeth in action. Chain runs bar first; action at *a* good, at *b* bad, at *c* good, at *d* bad.

In Fig. 9 we have the same sprockets as in Fig. 8, but the chain runs hook first. Here the action at *a* is bad, but the fact that the hook is not in contact with a tooth face at this point makes the consequent wear of little account. The action at *b* is good. The action at *c* is bad, but this is on the slack side of the chain and this bad action causes no wear. The action at *d* is good.

It is thus seen that there are two very bad points (*b* and *d*) where the chain runs bar first and only one serious trouble (*a*) when running hook first. Therefore, always run hook first in such a case.

Consider a drive when the sprockets are such as are usually furnished: These are ground to fit the new chain; when the latter stretches, both driver and driven are small as compared to it, and teeth *a* and *d* are now in action.

In Fig. 10 we have such a pair of wheels with the chain running bar first. The action at *a* is good; at *b* it is bad, but as there is no tension on the chain at this point, this is not objectionable. At *c* the action is good; at *d* it is bad. In this case, therefore, it would seem that the wear would be confined to the driven wheel and this is so in actual practice.

Only wear is on driven, caused by the bad action at *d*, this forms hook on *d* and break chain.

How to Run the Chain

Observe the same wheels with the chain running hook first, Fig. 11. The action at *a* is bad; at *b* it is good; at *c* it is bad, but not objectionable, because, as before, there is no tension at this point; action at *d* is good. Thus all the wear would seem to be on the driver as a result of the action at *a*. This is found to be the case; hence both theory and practice show that with the chain running *bar* first *driven* wheel wears, while with chain running *hook* first *driver* wheel wears.

Now, it is found that because the wear at *d*, running bar first, is caused by the link slipping up the tooth, it tends to undercut and form a hook and thus break the chain. On the other hand, the wear at *a*, when running hook first, is caused by the link slipping down the tooth, and the wheel will wear out completely without endangering the chain. It has also been proved that the driver, running hook first, lasts several times as long as the driven wheel when running bar first. As the driven wheel is in nearly every case much larger than the driver and the consequent wear on each tooth is less, it would seem that if the chain were run so as to wear the driven, the wear on the two wheels would be equalized. This would be poor practice for the reason that the driver, being smaller, is more cheaply replaced, and the repair acount will, therefore, be less running hook first.

In elevators, the head wheel acts as a driver, and the foot wheel simply as an idler, because it is doing no work. Therefore, run the chain bar first so as to favor the driver. On conveyers one wheel is always an idler, comparatively speaking, and the same reasoning holds as for elevators: the chain should run *bar first* in all cases.

These remarks apply equally well to all closed-end pin chains; the closed end corresponds to the hook and the pin end to the bar of the Ewart chain, or link-belt.

In general, therefore, on drives run *hook* first. On elevators and conveyers run *bar* first.

New Soldering Process

Every month or so there appears a new process for soldering; usually without flux, occasionally without heat, they rise and fall like the successive empires that we read about. The latest of which I hear is one which is well spoken of by some of the German technical papers, and which is said to be well adapted for soft soldering. The preparation used goes by the name of "Tinol," which might indicate that there was tin in it, and also that there was grease there too; in any case it is a pomade-like preparation which is laid on the part to be soldered, with brush or a stick, heat being then applied complete the process. The material is said to be free from acid, hence to cause no rusting of adjacent parts. The manufacturers claim, also, therefore, that it can be used for tinning sheet iron or brass. All of which sounds very encouraging, and is, to quote an old saying, "reliable if true."

Tool Making without Drawings

By Samuel Taylor

Two of the largest manufacturing plants in this country absolutely refuse to furnish the toolmaker with drawings other than a small blueprint to show the part to be made by die or jig. This blueprint is handed to a toolmaker with the information that the die to produce this piece is to be used in a certain press, and the distance between the slide and bed of press and the stroke are given, and that settles the instructions. A good many will argue that by allowing the toolmakers to do their own designing there will be all sorts of designs, some simple, some complicated. Is it not the same with draftsmen? Some draftsmen will design a fixture employing but four or five parts, very simple and cheap to make, easy to operate and rapid in production. Other draftsmen, in designing a fixture for doing the same work, will employ toggle joints, levers, cams, dovetail slides, eccentric shafts and special patterns for casting, altogether making a very complicated mess, and the production is no greater than could be accomplished by screwing two pieces of steel properly shaped to a pair of pliers. The tool-room foreman knows his men, and when he gives out a job he knows which of his men has had previous experience along this line, or knows that the one he assigns the job to has more than the average designing ability. Toolmakers, as a rule, are fairly well educated and well experienced in tool design, and they do not require a nicely made picture of a punch and die that tells them in detailed sketches to make a stripper, a punch, a die, a punch holder, round the corners to ⅛ inch radius, use two dowels and four screws to hold the stripper to the die, and numerous other foolish particulars. The toolmaker knows from experience that a stripper will not stay very long on the die unless it is screwed to it; also that the stripper cannot be taken off and put back exactly right unless there are dowels. Considering the above to be true, is it not a waste of money to employ a draftsman to spend a lot of unnecessary time and gray matter laying out an assembled and detailed sketch, placing dimensions where the toolmaker cannot measure, and where, in order to obtain the desired dimensions the toolmaker must add a number of detailed dimensions and subtract the sum from over all dimensions. We may find the dimension of the die to be, say, 1.285x0.8125 inch, and the same dimension on the punch that is to fit the die. A great many such dimensions are absolutely useless and are disregarded entirely by the toolmaker.

Method means the removal of backlash—the taking up of all loose-jointed connections.

Index Plate-drilling Machines

Automatic and Semi-automatic Machines Used by Well Known Manufacturers for Drilling Index Plates Accurately and Economically

SPECIAL CORRESPONDENCE

The accompanying illustrations show the machine used by the R. K. LeBlond Machine Tool Company, Cincinnati, O., for drilling their dividing-head index plates. This machine automatically drills all the holes on one side of the plate at one setting. The plate to be drilled is held on an arbor in the spindle at *W*. At the end of the spindle are mounted the master plates *A*, Fig. 3, which govern the number of divisions. The drill is carried by the head *B* and is driven from the countershaft through the pulley *C*. The pulley *D* drives the indexing mechanism and feeds the drill to the work with the cam on the end of the shaft *E*.

The machine drills from the center out, and after the first circle of holes is drilled, automatically engages the next succeeding master plate, and at the same time moves the head *F*, which carries the spindle and the master wheels crossways on the bed *G*, to which it is dovetailed, the proper distance for the next circle of holes. When all the circles are drilled, the feed and indexing are knocked off automatically.

Some of the Details

Fig. 3 is a longitudinal section through the center of the machine. Fig. 4 is a cross-section through the head carrying the master wheels and the bed, and Fig. 5 is a front view of the head and a layout of the mechanism for setting over the head and engaging the next succeeding master plate.

The drive for the indexing and cross movement will be understood from Fig. 4. The pulley *D* is connected with the spindle through a train of spur gears and worm and worm-wheel, the latter being attached to the spindle. A friction is disposed on the end of the worm-shaft which slips during the time the locking pin is engaging with the master wheel.

At the completion of a circle of holes, the disk *H* makes a complete revolution, which in turn actuates the segment. This segment, in connection with the links and ratchets, operates the spacing mechanism and the cross adjustment of the slide *F*. This mechanism is brought into operation at the completion of each circle, as follows:

A spring plug *I*, Fig. 3, engages the spiral cam on the clutch sleeve *J*, Fig. 4, and the plug is held in position by a slotted ring on the master plate. At a complete revolution of the plate, the plug jumps into the slot of the ring, and releases the clutch sleeve, which in turn engages the clutch teeth, and sets the mechanism in motion.

The Indexing Mechanism

There is a locking pin for each master plate, only one of these, however, being in operation with its plate at one time.

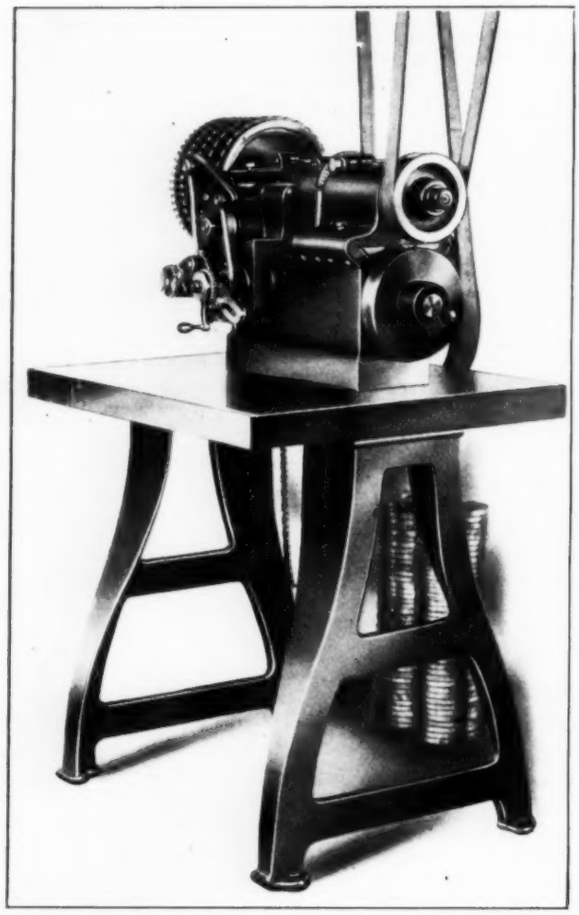


FIG. 1. LEBLOND AUTOMATIC INDEX DRILLING MACHINE

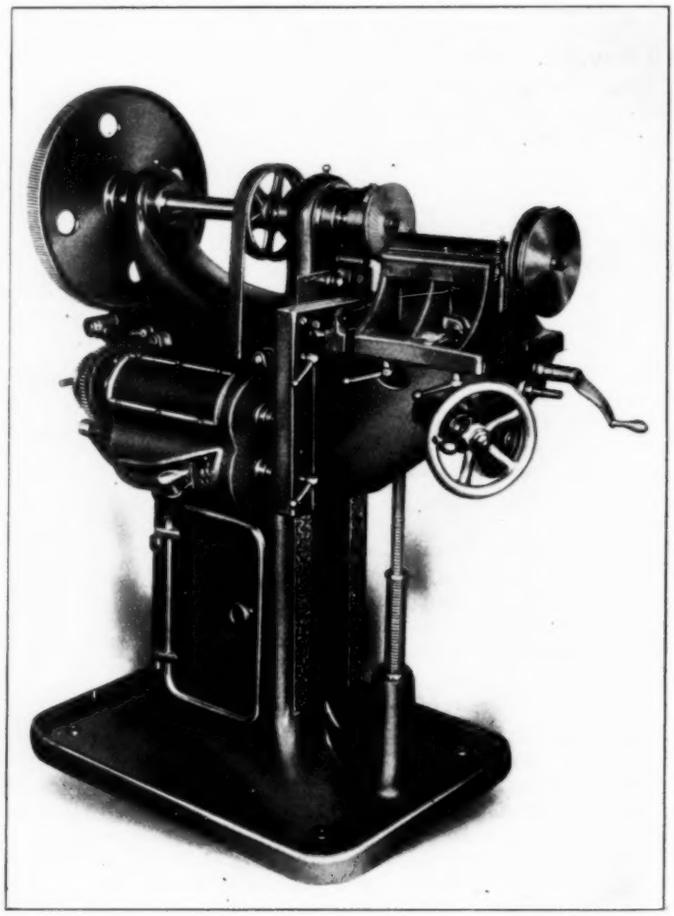


FIG. 2. HENDEY INDEX PLATE-DRILLING MACHINE

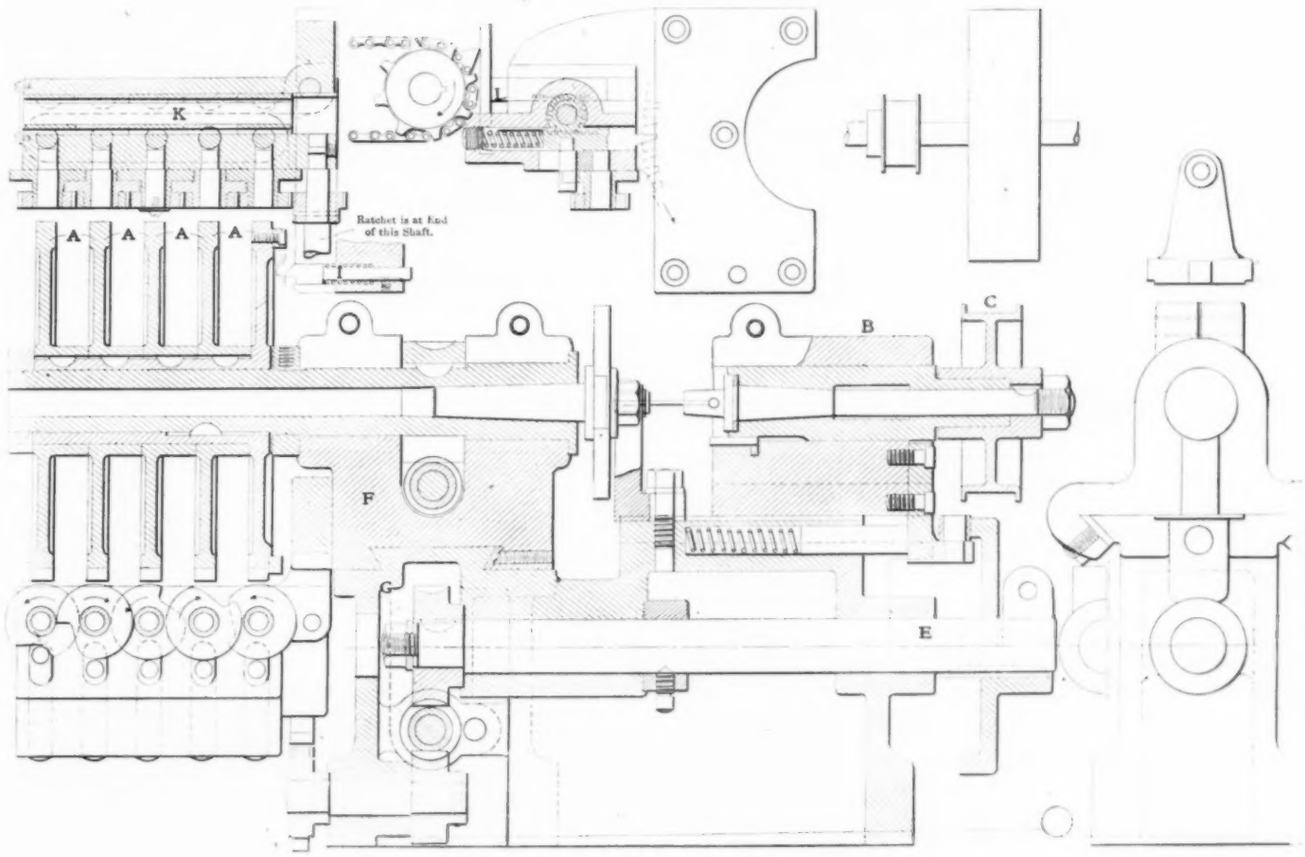


FIG. 3. CROSS-SECTION OF THE LEBLOND MACHINE

The others are held out of engagement with the cams, as seen in Fig. 3. At the complete revolution of the master plate, the cams are given one-sixth of a revolution with the segment and ratchet, as described above, which brings the pin, for the next plate, into engagement.

The mechanism for spacing from tooth to tooth, is also shown in Fig. 3. Each locking plunger engages with an individual pinion that journals loosely on the shaft *K*. Keyways cut in the pinion are made wide enough to allow the cam to hold the other locking plunger out of engagement without interfering with the movement of the shaft *K*. The tailed plunger, which gives motion to the pinion cut on the shaft, is raised by a large link in the chain on the sprocket wheel. A chain is used to give a quick lift and drop to the plunger, which in this case is necessary.

The Hendey Index Driller

The machine used by the Hendey Machine Company, Torrington, Conn., for drilling its index plates is shown in Fig. 2 and bears quite a resemblance to a milling machine. The drilling head with its long bearing is mounted on the knee and is driven independently by a belt from the countershaft. The drill-spindle bearing is adjustable in its support to give any depth hole as the carriage is fed in and out on the knee. The feed mechanism is driven from the back and the gear box in the side controls the indexing according to the table in the curved panel above the handle. Change gears enable any combination of holes to be indexed.

The plate to be drilled is mounted on the spindle as shown, the knee adjusted to get the drill at the right distance from the center, the drill and the indexing

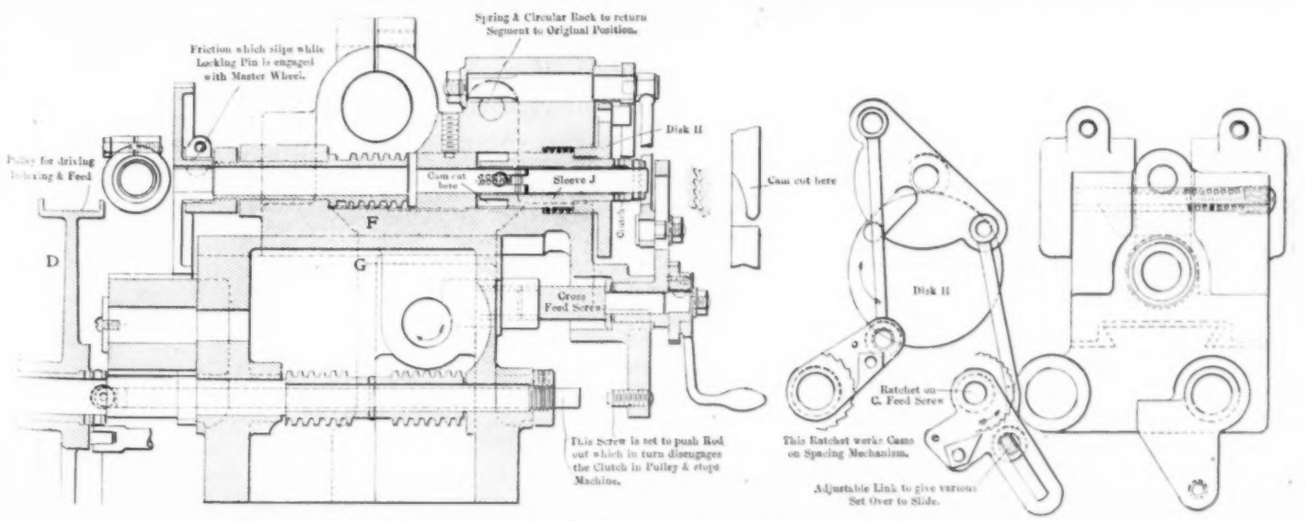

Spring & Circular Rack to return Segment to Original Position.
Friction which slips while Locking Pin is engaged with Master Wheel.
Pulley for driving Indexing & Feed
Disk H
Cam cut here
Sleeve J
Cam cut here
F
D
G
Gross Feed Screw
This Screw is set to push Rod out which in turn disengages the Clutch in Pulley & stops Machine.
Disk H
Ratchet on C. Feed Screw
This Ratchet works Cams on Spacing Mechanism.
Adjustable Link to give various Set Over to Slide.

FIG. 4. DETAILS OF AUTOMATIC INDEX PLATE-DRILLING MACHINE

mechanism started up and the work begins. The drill spindle goes forward, drills the hole and returns, the plate is indexed and the operation repeated until the whole row is drilled. Then the knee is adjusted for the next row and the process continues. The belt over the small pulley on the spindle is simply a strap brake to prevent any back lash in the gearing affecting the indexing. While the machine is not full automatic, it is very efficient and accurate.

Turning Cone Pulleys

By Geo. K. Atkinson*

It is quite common practice to use multiple tools for turning cone pulleys, but to get good results requires a lathe designed especially for the purpose. In the method employed by The John Steptoe Shaper Company, of Cincinnati, Ohio, work of a very high degree of accuracy is produced at a reasonable labor cost and the upkeep of tools is reduced to a minimum.

As seen in Fig. 1, the cones are first chucked true with the inside in the chucking lathe, with the large end of the cone toward the turret. It is then bored out, reamed and the hub faced with the regular turret tools.

The compound rest is now set and the small step is chamfered to 60 degrees and faced with a round-nose tool. The pipe center, which is provided with a ball-thrust bearing and fits the outside of the tailstock spindle, is brought up and adjusted to fit snugly into the small end of the cone which gives a rigid support to both ends of the cone, thus eliminating the vibration so evident in this class of work.

The cone is then turned off with a roughing tool of high-speed steel, using a very coarse feed, after which it is finished with the forming tool *J*, which has a very slight curvature on the front edge and a small lip formed on its left side to

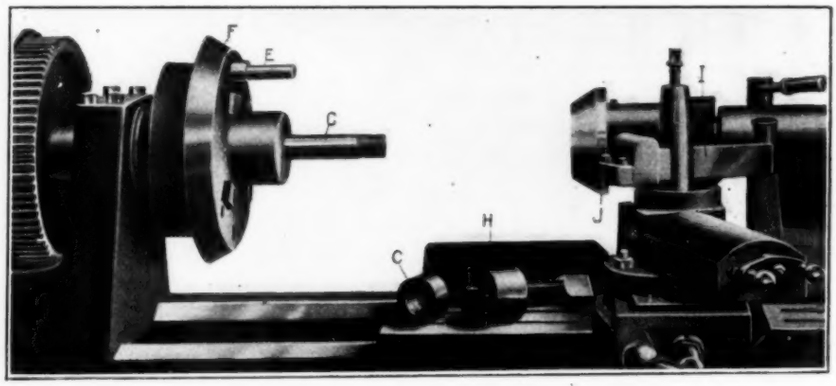


FIG. 2. APPARATUS FOR MOUNTING THE PULLEYS FOR TURNING

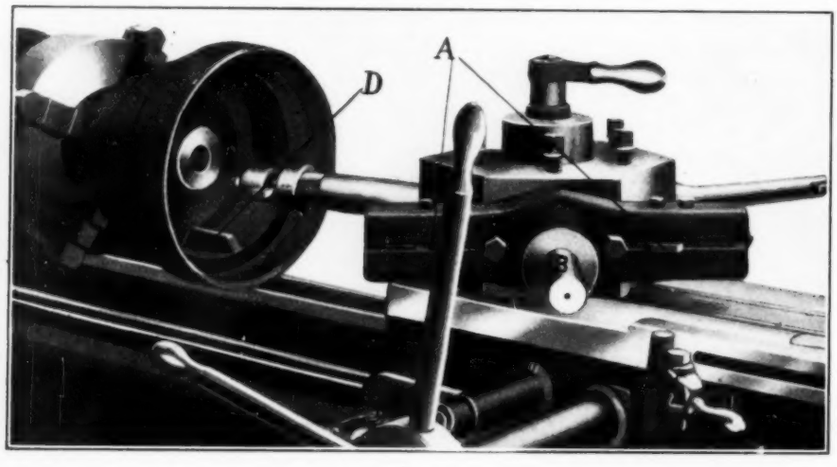


FIG. 1. BORING AND FACING PULLEYS IN TURRET LATHE

Then the inside of the large step is chamfered to 60 degrees and the end faced with the tool shown at *A*, the pulley being supported with the pilot shown at *B*. The pulleys are then hand-reamed, after which they are ready to be turned. The method of turning is shown in Fig. 2.

The work is mounted on the arbor *C*, which is threaded on its outer end, and revolved until the lug *D* (Fig. 1) comes in contact with the driver *E* (Fig. 2). It is then forced up tightly on the 60-degree cone *F* by means of the nut *G* and wrench *H*, shown lying on the carriage in Fig. 2.

*Superintendent of the John Steptoe Shaper Company, Cincinnati, Ohio.

under-cut the sides of the cone steps for belt clearance.

The forming tool is fitted into the groove as shown and clamped to the seat of the holder *I* by means of two cap-screws. The holder *I* is a forging of tool steel and is spring-tempered at *K* to add to its elasticity and obviate chatter. In use the tool is set at an angle to give the desired amount of crown and fed into the work until one-half of the width of the step is finished. It is then set over at the proper angle and the other side of the step is finished in the same manner. The sides are then undercut with the lip on the left side of the tool, which completes the pulley, the entire machining being accomplished in two chuckings.

We have been using this method for some time and find that the cones come true to within 0.002 inch, leaving an excellent finish, and require practically no filing and reduce the polishing to a minimum.

Working Rubber

By A. N. Hammond

For the small rolls, a small speed lathe and a few sheets of coarse and fine sandpaper will give a good finish approximately to size, very cheaply. In rubber works where absolute accuracy is desired, a small automatic grinding machine is used. For large rolls nearly any large lathe can be adapted by the use of an overhead-driven roll which is used to drive a small emery-wheel attachment fastened to the carriage, the motion of the carriage being sufficient to keep the belt in line. Most rolls, hard or soft, have a slight crown any lathe hand can adjust to give the desired crowning effect.

For boring valves, etc., both medium and hard can be bored with an ordinary twist drill. For the softer kinds, a thin boring tool seems to give the best results, only each time the tool is used it needs wetting down with water. If you visit a rubber works, never wet your knife to cut any rubber; outside of the rubber works use all that can be made to adhere at any and all times.

Some of the largest paper mills in the country are using the second method. As to patching rolls, etc., this can be done with compounded rubber, bisulphide of carbon, anhydrous naptha and chloride of sulphur, water being used when vulcanization has progressed as far as desired.

The new method of carbonizing armor plate, the invention of an American naval officer, which is at present provoking widespread attention, will sooner or later possibly be applied to steel products of smaller dimensions.

The Construction of Graphical Charts

How Charts Are Plotted from Equations by Analyzing, Substituting Values and Selecting Scales—Examples, Including "Alinement" Chart

BY JOHN B. PEDDLE

Much of the work of calculation done by the engineer or designer is in the application of a limited number of formulas to a large variety of different conditions, involving merely the substitution of different variables in identical equations. In such cases the use of numerical tables or graphical diagrams will greatly shorten the time necessary to obtain the results, reduce the mental wear and tear, and minimize the chances of error. Many of these graphical charts have been published of late years in the various technical periodicals, but it is highly desirable that the man engaged in work requiring their use should possess some knowledge of their underlying principles in order to construct charts suited to his individual needs. It goes without saying that there is little or no economy of time in constructing these charts if they are to be used on only a few occasions; the advantage will not be apparent unless they are to be used repeatedly for solving the same problem for a large number of varying conditions.

In this article it is my intention to describe only a few fundamental and typical forms of the graphical chart, such as may be understood by anyone with a little mathematical knowledge. In practice they will have to be modified or combined to suit special cases. Practice and a certain amount of ingenuity in putting the equations into workable forms are essential to success; no general rules for guidance can be laid down.

To those who wish to pursue the subject farther than I have carried it here and who read French, Maurice d'Ocagne's "Traité de Nomographie" is strongly recommended. It is a mine of useful and curious information on this subject, and will richly repay anyone for the trouble of reading it.

The Simplest Form

The simplest form of graphical chart is that which is frequently used to compare different systems of units of the same character with each other. It is often used, for instance, to show the relative values of temperatures as measured on the Centigrade and Fahrenheit scales.

It is exceedingly simple to construct and to use.

If an equation containing but one variable and its function is to be represented, one side of a straight line is graduated to represent one of the variables, and the equation solved to give as many corresponding values of the other variable as are needed. These are laid off on the other side of the line, and in order to read the chart we have merely to run across the line from one scale to the other to get corresponding values of the variables. It may be used for a variety of equations, such as $y = a\,x + b$, $v = \sqrt{2\,g\,h}$, $s = \frac{1}{2}\,a\,t^2$, $a = \frac{\pi}{4}\,d^2$, $y = log.\ x$, $y = sin.\ x$, etc.

For purposes of illustration I have plotted the two charts shown in Fig. 1 to represent the corresponding values of the diameter and area of the circle. Such a chart is of very little practical value, since a table of circular areas will give the desired results with much greater accuracy and convenience. I have introduced it here partly to illustrate the chart, but mainly for the purpose of discussing the relative merits of the two systems of graduation which are shown.

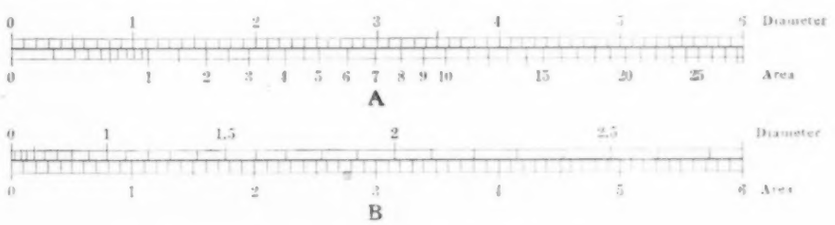


FIG. 1. PLOTTED SCALES OF THE DIAMETER AND AREA OF CIRCLES

It will be noted that in Chart *A* the diameters are expressed in equal scale divisions, and the areas by divisions which diminish in size as the areas increase. In *B* the areas are represented by equal divisions and the diameters by divisions which increase in size as the diameters increase. The accuracy with which we can read such charts will evidently depend upon the size of the divisions. In general, the conditions represented in *A* are preferable for, although the absolute error in reading the upper part of the unequal scale will be greater than in the lower part, the *percentage* of error throughout the scale will be more nearly equal with *A* than with *B*.

On the other hand, if most of our readings are to be about the upper part of the scale, it may pay us to use the *B* arrangement in order to take advantage of its larger divisions.

Let us now take an equation of the form

$$y = b \pm a\,x. \qquad (1)$$

This equation, when plotted on rectangular coördinates, gives us a straight line. That is, if we lay off values of y on the vertical or Y-axis and of x on the horizontal or X-axis and erect perpendiculars to these axes at corresponding values of x and y, these perpendiculars will intersect at points which lie on the same straight line. Thus in Fig. 2, line 7 corresponds to the equation

$$y = 10 + \tfrac{1}{2}\,x.$$

If we erect a perpendicular to any point on the X-axis, say 40, find its intersection with line 7, and then run horizontally to the Y-axis we will get the corresponding value of y as 30.

If we give b different values, say 15, 20 and 25, leaving a the same, we get the parallel lines 6, 5 and 4, which intersect the Y-axis in the new values of b. If we change a we change the slope of the line; if we make it negative we get the downward sloping lines 3, 2 and 1.

Suppose we make a in the equation equal to 1. Our sloping lines will now run at an angle of 45 degrees. Taking a new chart to avoid confusion we will have something like Fig. 3. Two sets of diagonals are shown; one sloping up as we move to the right and the other sloping down. The first corresponds to

$$y = b + x \qquad (2)$$

and the other to

$$y = b - x \qquad (3)$$

According to the first equation we have y as the sum of b and x. If, therefore, we enter on the X-axis at, say 24, run up as indicated by the heavy line to diagonal 15 and thence to the Y-axis, we will read the sum, or 39. Subtraction would be performed by going in the opposite direction or by using the b lines designated by negative values.

Right here it might be well to suggest that the quantities represented by the diagonal lines in this, or any other, chart should be such as are not likely to vary much, and are capable of being expressed in round numbers. Fractional values can be much more easily picked off of the scales on the axes. A large number of diagonals on the drawing is very likely

to cause confusion in reading, and will certainly entail additional labor to construct.

Let us now consider the other set of diagonals, corresponding to

$$y = b - x.$$

This may also be written

$$b = x + y. \qquad (4)$$

It indicates that if we enter the X- and Y-axes with two numbers to be added and run the perpendiculars out to their intersection, this intersection will be found on the diagonal numbered with the sum. Thus entering the X- and Y-axes at 26 and 44, and running as indicated by the heavy lines, we find the intersection on diagonal 70. Next suppose $b = O$, and give a different values. The diagonals will now be a series of radiating lines from the intersection of the X- and Y-axes. This is shown in Fig. 4. Here, making their values 10 times as great, as shown in the parentheses, and also give the graduations on the Y-axis a double set of numbers, we may be able to keep the dimensions of the chart within reasonable limits and also use diagonals which are more favorably disposed for accurate reading. In any case, however, there will be an unavoidable crowding together of the diagonals near the origin which will make the readings about the low numbers difficult, if not impossible.

There was no real need to suppose that b in the equation was zero. It was done merely for convenience in illustrating the point I wished to explain. If b had had any value, positive or negative, we should have had the same set of radiating lines, but their point of intersection would have been shoved up or down the Y-axis by the value which we gave to b.

must be interpolated by the eye. It will be readily seen that this method is not at all suited to any case in which the desired number of products is large, since the labor of drawing in the curves would be prohibitory.

Note that curves 1 or 10 might be used as tables of reciprocals.

Next let us consider a case in which some power of one of the quantities is involved. We will select a case involving several multiplications in order to show how some of the principles already discussed are applied. This will be done in some detail in order to clearly show the process of attacking a simple problem.

Proportions of Band Brakes

Take the formula for the band brake

$$P = A\,T\,(1 - 10^{-0.00758\,f/a}),$$

in which P represents the resultant

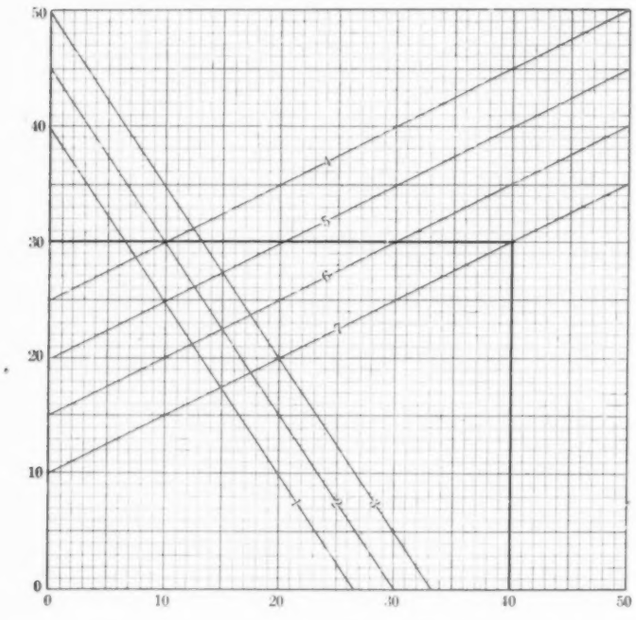


FIG. 2. LINES PLOTTED FROM THE GENERAL EQUATION $Y = B \pm AX$

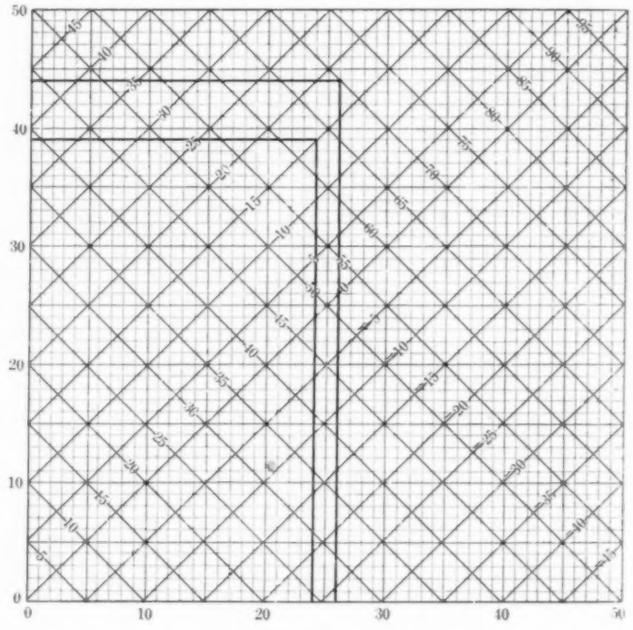


FIG. 3. LINES PLOTTED FROM THE GENERAL EQUATION $Y = B \pm X$

as our equation informs us, the chart may be used for multiplication. Entering the X-axis at 2, running up to the diagonal 3 and from there to the Y-axis we read the product, 6. Division is, of course, performed by going through the chart in the opposite direction.

This chart, while simple in appearance, is not very practical where the multipliers differ greatly in value. It is easily seen that if we wish to multiply any number on the X-axis by 10, it will be necessary to have the chart 10 times as high as it is wide. Moreover the intersection of the vertical lines with the diagonals near the 10-line is very acute and necessarily difficult to read accurately. The best position for the diagonal for this purpose is on or near the 45-degree angle.

These difficulties may be partly overcome by changing the scale values. If we renumber the diagonals from 0.1 to 1

Let us now investigate another form of chart for multiplying, writing our equation

$$a = x\,y \qquad (5)$$

If we give a a definite value and find corresponding values of x and y, it will be found that perpendiculars erected at these corresponding points will intersect on a curve called the equilateral hyperbola. For each different value of a we will have a different curve.

A chart constructed with them, like Fig. 5, could therefore be used for multiplication and, of course, for its converse division. We have only to pick out the numbers to be multiplied on the two axes, follow up their perpendiculars to their point of intersection, which will be found on the curve numbered with the product. Should this point fall between two curves, instead of on one of them, the product

tangential pull on the brake, A the area of the cross section of the brake band in square inches, T the tension in the tight side of the band in pounds per square inch, f the coefficient of friction (0.18 in the case of iron on iron) and a the arc of contact of the band in degrees.

Inside the parenthesis in our equation there is only one quantity which need be considered as a variable, a the arc of contact; f will be constant for any given materials for band and drum and, as indicated above, will be taken as 0.18. Under these circumstances, instead of drawing a separate line or set of lines for each quantity inside the parenthesis, we need only draw one line for the parenthesis as a whole, getting the different values for plotting this line by letting a vary. We will have to assume the limits within which this variation is to take place. Suppose we take these as 200 and 300 de-

grees. Then solve the parenthesis for every 10 degrees between these limits.

In Fig. 6 the results of these calculations are shown plotted as ordinates on the chart, while the corresponding arcs of contact are taken as abscissas. In laying off the latter, one small scale division on the horizontal scale is used to represent two degrees of arc. The vertical scale will need to be large as the values of the parentheses only vary from 0.4666 to 0.6103, and this, if plotted to a small scale, would make a very flat and therefore undesirable curve.

Suppose we make one small scale division on the vertical scale equal to 0.01. This has been done on the chart, and the curve drawn through the points thus found. These values must now be multiplied by the assumed values of T, the tension per square inch in the band. According to one authority the safe values for T will range from 4500 to 6500 for wrought iron, and from 8500 to 11,500 for steel. We have therefore to provide for a total range of 7000 pounds and we will cover this by steps of 500 pounds. We will adopt the multiplying method shown in Fig. 4, making the radiating lines stand for the different tensions. They must converge to a point somewhere on the zero line of the curve just drawn, and this point may be chosen at will. In reading the chart we must run up or down a vertical line until we strike the curve, and then go horizontally until we reach the desired T-line. It is evident that all the T-lines must be in such a position that they may be intersected by any horizontal drawn from the curve. They must be so drawn that the tangents of the angles they make with the vertical will be proportional to the tensions they represent. Let us run up ten of the large divisions from the zero line and then horizontally 4½, 5, 5½, 6, etc., of the large divisions, corresponding to tensile stresses of 4500, 5000, 5500, 6000, etc., so as to get the lines well spread out. If we take the point of convergence at 14 large divisions to the right of the left-hand edge of the chart the conditions we have imposed above will be fulfilled, and this has accordingly been done. The results of this multiplication will be read on the horizontal axis, and they must next be multiplied by the assumed values of A, the area of the cross section of the band.

We could use the same point of convergence for the A-lines as for the T-, but inasmuch as this would cause some confusion in reading the diagram, it will be better to use some other center, which however, must be located on the vertical line passing through the T center. According to the authority quoted above, the thickness of the band for ordinary cases should vary between 0.08 inch and 0.16 inch, corresponding, roughly, to No. 12 and No. 6 Brown & Sharpe gage. If our bands are not to be less than 1 inch, nor more than 3 inches in width, the maximum variation in area will be between 0.08 square inch and 0.48 square inch. For convenience let the areas vary by steps of 0.04 square inch, although any other size of step might have been chosen. This will give us 11 lines which must be so drawn that the tangents of the angles they make with the horizontal will be proportional to 0.08, 0.12, 0.16, etc.

We must now determine the limits within which our results, the desired values of P, must fall. For the least area, 0.08 square inch, the least tension, 4500, and the smallest contact angle 200 degrees, we have $P = 168$. For the largest values of the same quantities we have $P = 3369$. These values of P will be read on a vertical scale. It will be found that if we allow 1 large division on the vertical scale to represent 200 pounds it will give us a convenient scale length and readings may be made with an accuracy which is sufficient for all practical purposes. The length of the vertical scale will thus be about 17 of the large divisions.

Therefore going up, 17 large divisions from the zero of the curve we locate the center for the radiating A-lines on the vertical line which passes through the center of the T-lines. From this center we go 10 large divisions to the left and, going down 2, 3, 4, 5, etc., large divisions, (proportional to 0.08, 0.12, 0.16, 0.20, etc.,) we locate the points through which the A-lines must be drawn from their center. By this arrangement they will cover the desired length on the scale of P. Our chart is now complete except for lettering the lines and scales. The left-hand scale must of course, be lettered so as to make each large division represent 200 pounds pull.

To read the chart, enter at the bottom or top at the assumed arc of contact and run up or down to the curve, from there go horizontally to the desired tension in the band, then vertically to the area line, and then horizontally to the vertical scale representing the tangential pull. Or, if the pull, arc of contact and tension are known, enter as before at the arc of contact, run vertically to the curve, thence to the tension line, and the intersection of the vertical through this point with the horizontal drawn from the desired pull will be on or near one of the area lines, thus giving the necessary size of the band.

It is obvious, that for all practical purposes, our chart might have been trimmed off on the right-hand side at the end of

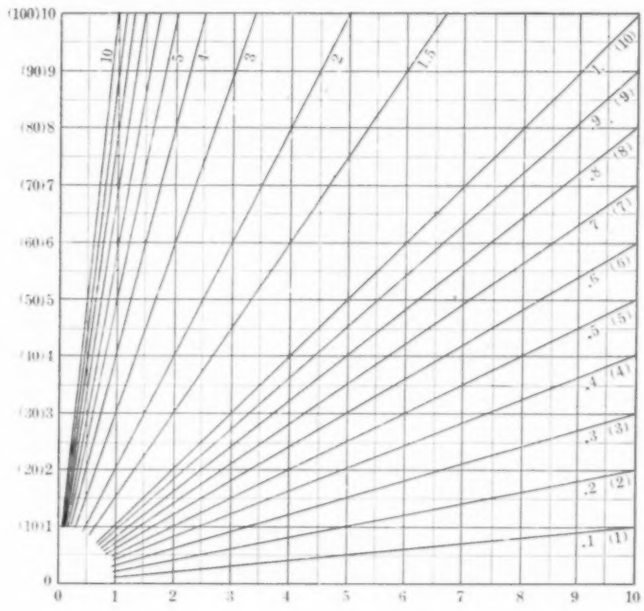


FIG. 4. LINES PLOTTED FROM THE EQUATION $0 = AX + Y$

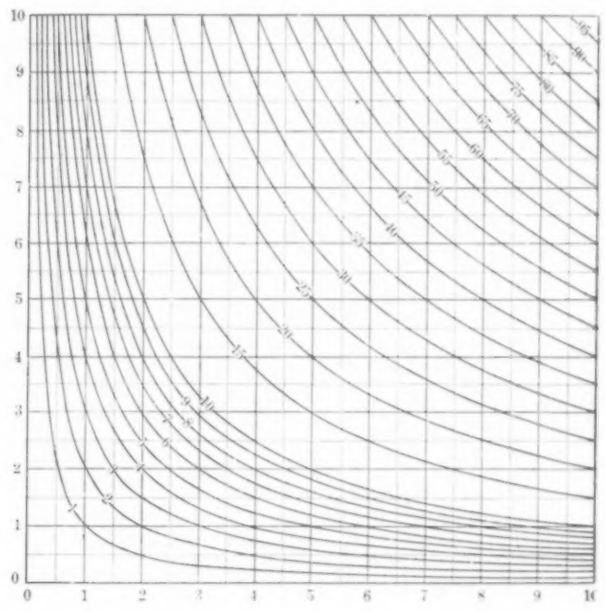


FIG. 5. CHART FOR MULTIPLICATION AND DIVISION, PLOTTED FROM THE EQUATION

the curve, so as to omit all of the diagram not sectioned with the small divisions, also that there is no need of continuing the T-lines above or below the curve.

There is no necessity, in these charts for having the scale divisions equal, as has been the case in all the charts except the first. If we admit this there is a distinct advantage in many cases in having them irregular.

Equation of the Focal Distance of a Lens

For instance, take the formula connecting the two foci of a lens with its principal focus

$$\frac{1}{f} + \frac{1}{f'} = \frac{1}{p}$$

where f and f' are conjugate focal distances and p the principal focal distance.

Make

$$x = \frac{1}{f}, \; y = \frac{1}{f'}, \text{ and } b = \frac{1}{p}.$$

The above equation becomes $x + y = b$ which is identical with equation (4) above.

We have, in this case, to lay out on the X- and Y-axes the reciprocals of f and f' and draw in the diagonals as shown in Fig. 7, just as we did in Fig. 3. Knowing the principal focal distance of our lens, we select the diagonal corresponding to it, enter the X-axis, say, at the distance of the object from the lens, run up to the diagonal, from there to the Y-axis and read off the distance at which the object will be in focus.

Logarithmic Charts

A more important case is where the divisions are laid off to a logarithmic scale. Paper ready ruled in this way may now be had from dealers in mathematical instruments and is valuable for many purposes. On it, many problems which would have to be solved by tediously drawn curves may be worked with ease by straight lines.

Let us return to equation (5) $a = xy$. This may also be written $log.\, a = log.\, x + log.\, y$ which is identical with (4), the equation for a straight line. The paper in question is graduated on its horizontal and vertical axes so that the lengths from the origin are equal to the logarithms of the numbers placed opposite the graduation marks.

If in Fig. 8 we connect 2 on the vertical axis with 2 on the horizontal axis, 3 with 3, and so on, we get a chart similar to Fig. 3, which was used for addition, but in this case is for multiplication. It also bears some resemblance to Fig. 5, but the equilateral hyperbolas used there are replaced by straight lines. To use the chart enter at the X- and Y-axes with the numbers to be multiplied and follow out the perpendiculars at these points to their point of intersection, which will be found at the diagonal numbered with the product.

We might also draw the diagonals so as to slope upward from left to right instead of downward, as shown on the same chart. This is identical with the second form of addition chart of Fig. 3, and may also be used for multiplication. Thus, entering on the X-axis with the multiplicand we run up till we strike the diagonal numbered with the multiplier, and thence over to the product on the Y-axis. Such paper is also very convenient for handling equations containing powers and roots of the variables, and especially where these powers and roots are fractional.

For instance, $y = x^2$ may be written $log.\, y = 2\ log.\, x$.

This indicates that a line drawn so that its tangent with the horizontal is 2 could be used for squaring numbers on the X-axis, or conversely for extracting the square roots of numbers on the Y-axis. This is shown in Fig. 9. The top of the diagram is bisected, and a line drawn to this point from the origin, enabling us to find any square not exceeding 10. Entering at 2 on the X-axis and running up till we strike this line and from there to the Y-axis we read 2^2, or 4.

To get squares greater than 10 we should have to extend our chart above the 10-line. It would be exactly similar, however, to the part below, and it is therefore only necessary to lower our squaring line so as to cut the base of the chart in the middle, and make it pass through the upper right-hand corner. We thus get a chart which may be used for getting the square or square root of any number, the only thing to be noted in the latter operation is that we must use one or the other section of the line according to the position of the decimal point. If the number whose square root is desired has one, or three, or five places (any odd number) before the decimal point, use the first section of the line; if it has two, or four, or six places (any even number), before the decimal point, use the second section.

From what has been said it is plain that the cube line should be drawn by dividing the upper and lower edges of the diagram into three parts so as to make the tangent of the angle of slope 3. Here there will be three lines crossing the diagram. For getting cube roots the first section should be used where the number of places before the decimal point is 1, 4, or 7, etc., the second section where the number of places is 2, 5, or 8, etc.,

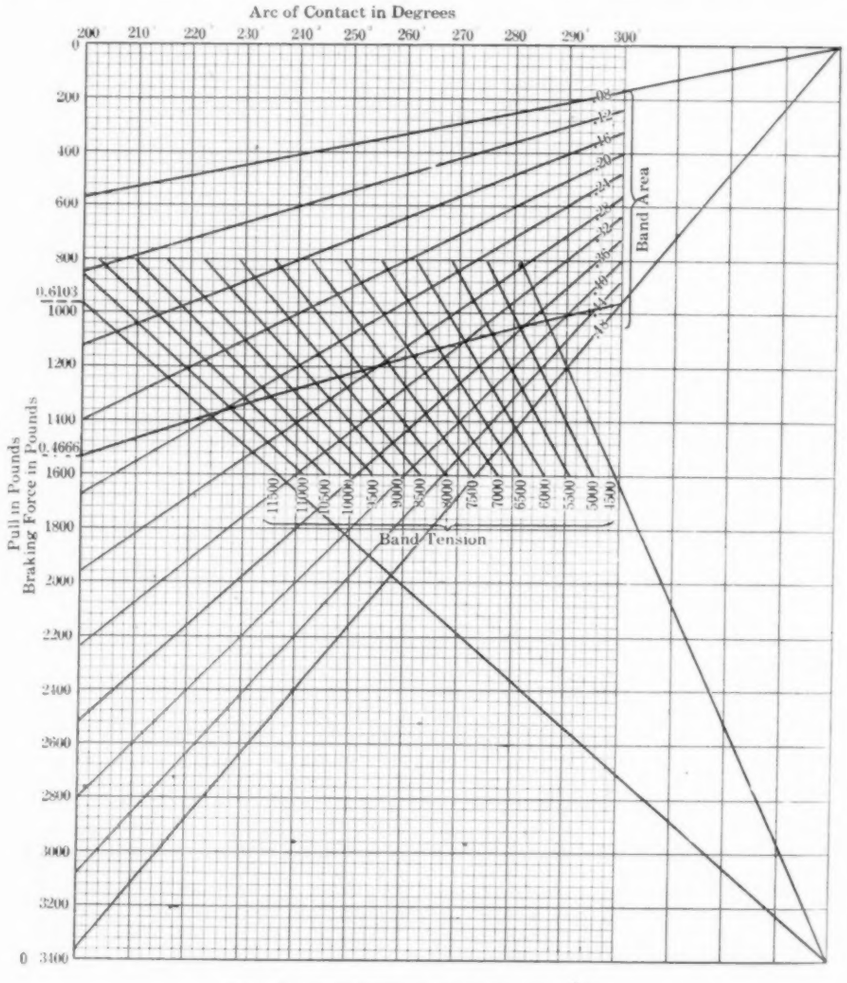


FIG. 6. PROPORTIONS OF BAND BRAKES

while the third section is used where the number of places is 3, 6, or 9, etc.

For getting fractional powers or roots the tangent of the angle of the slope must, of course, be equal to this fractional exponent. Equations such as $p\,v^n = c$ are easily solved. In Fig. 9 the line representing $p\,v^{1.41} = 10$ has been drawn for purposes of illustration, v being read on the horizontal and p on the vertical axis. On the same chart a line has been drawn for getting circular areas, showing the extreme simplicity of the method. Diameters are read on the horizontal- and areas on the vertical-axis.

In Fig. 10 is shown the application of this paper to the formula for the section modulus of a beam of rectangular section

$$Z = \frac{b\,h^2}{6}.$$

In this chart, values of h are read on the base line, b on the diagonals and Z on the vertical or Y-axis. For the sake of clearness only two of the diagonals representing b have been drawn. They are for $b = 2$, and $b = 4$.

In reading any of the logarithmic charts here given, significant figures only will be found. No definite rules need be given for finding the position of the decimal point. As with the slide rule, it needs only the application of a little common sense.

There is a large number of variations possible with the types of chart which I have described, and also a large number of types differing radically from them and useful for special forms of equation. The necessary limits of an article of this description preclude any attempt to cover them here.

The Alinement Chart

One other type, however, has received some attention of late years, and as it presents certain decided advantages for some purposes a brief description of certain of its fundamental properties will be given. It is known as the alinement chart. In all the work we have done so far the necessary lines were plotted on what are known as rectangular coördinates, that is, the axes on which the values of x and y were plotted met at a right angle. This is by no means a necessary condition. The axes may be parallel, and, in fact, I have a little book in which the author has developed a system of coördinate geometry

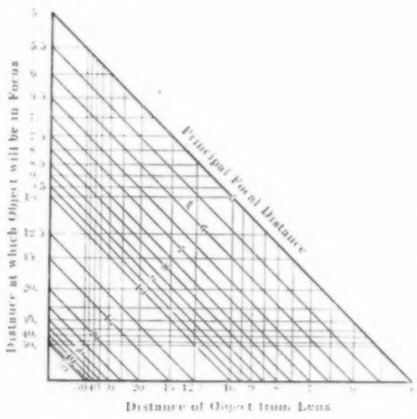


FIG. 7. FOCAL DISTANCES OF A LENS

based on parallel instead of rectangular coördinates.

To aid us in understanding this form of chart let us take a simple equation of the form

$$a\,u + b\,v = c \qquad (6)$$

where u and v are variables and a, b, and c are constants. This is the equation of a straight line where rectangular coördinates are used. To illustrate, let us assume $a = 4$, $b = 6$, and $c = 60$, and draw the line represented by the equation as shown in Fig. 11.

Since u and v may have any values let $u = 0$, then $6\,v = 60$ and $v = 10$. Again letting $v = 0$, $4\,u = 60$ and $u = 15$. This gives us the coördinates of two points on the line, one on each axis. Lay off $u = 15$ on the Y-axis and $v = 10$ on the X-axis and join them. Then for $v = 4$, $u = 9$, as shown by the heavy line on the chart.

Now let us lay off the same quantities on the parallel axes in the second chart of Fig. 11. On the axis marked $A\,u$ lay off 15 and join it to $v = 0$ on the $B\,v$ axis. Lay off $v = 10$ on the $B\,v$ axis and join it to $u = 0$ on the $A\,u$ axis. These two lines meet at the point marked p. It will be found that all lines joining corresponding values of u and v, as found from the equation, will pass through the same point. Or, if we take 4 on the $B\,v$ axis and join it with p, this line prolonged will cut $A\,u$ at 9, giving us the same result that we got by the other chart.

Thus, what was the equation of a line with the rectangular system, becomes now the equation of a point. Keeping a and b constant and changing c gives us, with the rectangular system, a series of parallel lines. With the parallel coördinates this merely moves the point p up or down on the line $C\,p$. This line is called the "support" for the points of intersection p. On the other hand, changes of a or b will shift p to the right or left of the support $C\,p$. To establish the point p it will generally be sufficient to solve the equation for a few easily determined values of u and v, lay them off on their axes and join corresponding points as has just been done. Or, it may be worked out analytically as follows:

Let the position of the point be supposed to be located by reference to rectangular coördinates, of which the line $A\,B$ represents the X-axis, and the line through O midway between $A\,u$ and $B\,v$ and parallel to them the Y-axis. Draw a horizontal

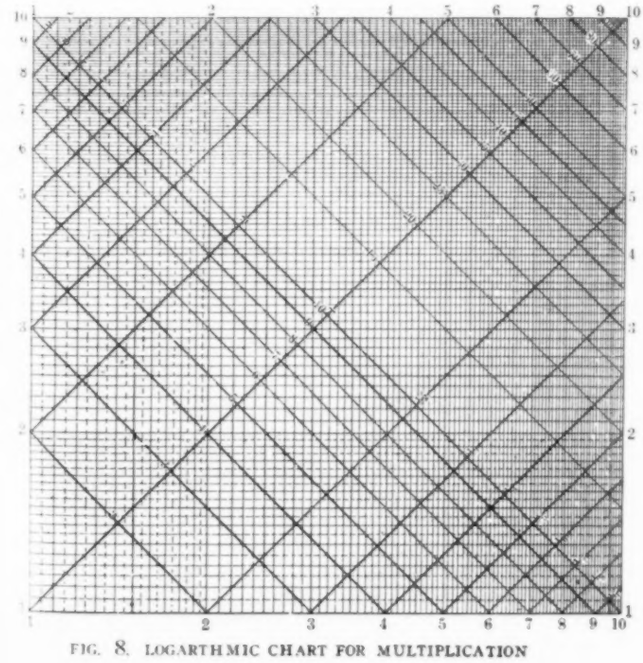


FIG. 8. LOGARITHMIC CHART FOR MULTIPLICATION

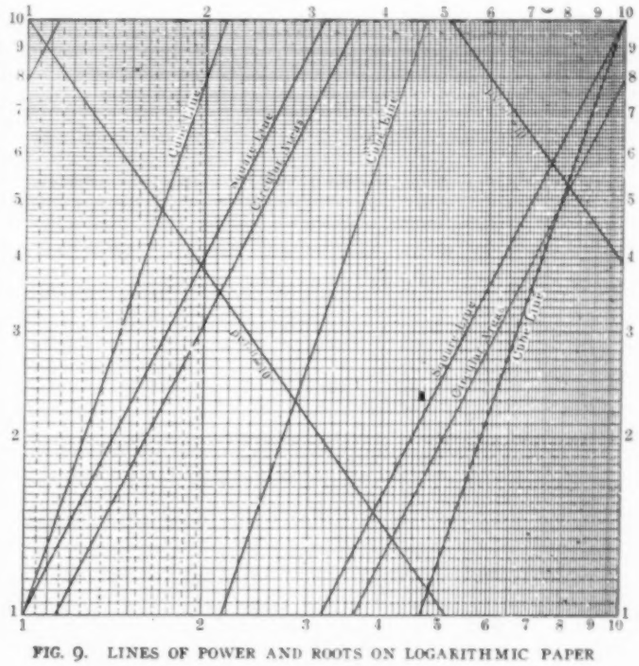


FIG. 9. LINES OF POWER AND ROOTS ON LOGARITHMIC PAPER

line through p. It will intersect the lines $A\,u$ and $B\,v$ at the same hight above $A\,B$ as p. Call this distance y.

Equation (6) may now be written

$$a\,u + b\,v = a\,y + b\,y = c,$$

or

$$y = \frac{c}{a+b}. \qquad (7)$$

This gives the distance of the point p above $A\,B$.

If x', y' and x'', y'' are the coördinates of two known points on a line, analytic geometry teaches us that

$$\frac{x - x'}{x' - x''} = \frac{y - y'}{y' - y''}.$$

Let us apply this to the two lines originally drawn to locate p, and call the distances $O\,A$ and $O\,B$, $-d$ and $+d$, respectively. The coördinates of the points at the two ends of one of the lines are: $x' = -d$, $y' = \frac{c}{a}$, and $x'' = d$, $y'' = O$.

Therefore

$$\frac{x+d}{-d-d} = \frac{y - \frac{c}{a}}{\frac{c}{a} - O}.$$

For the other line $x' = -d$, $y' = O$, and $x'' = d$, $y'' = \frac{c}{b}$ are the coördinates of the ends, and its equation will be

$$\frac{x+d}{-d-d} = \frac{y - O}{O - \frac{c}{b}}.$$

Combining these equations so as to eliminate y we get

$$x = \frac{d\,(b-a)}{b+a}. \qquad (8)$$

thus giving us the distance of the point from the vertical line through O. It shows, also, that this distance is independent of c, and that, therefore, however c varies (if a and b are constant), p will always lie on the line $C\,p$.

The actual location of the various points on this line may be found by solving the equation for y for different values for a and b, or as said before, by joining up corresponding points on the $A\,u$ and $B\,v$ axes by lines whose intersection with the locus, or support, of p will give us the desired points.

A practical example worked through will, perhaps, give us a better idea of the methods used than we should gain by a purely abstract discussion.

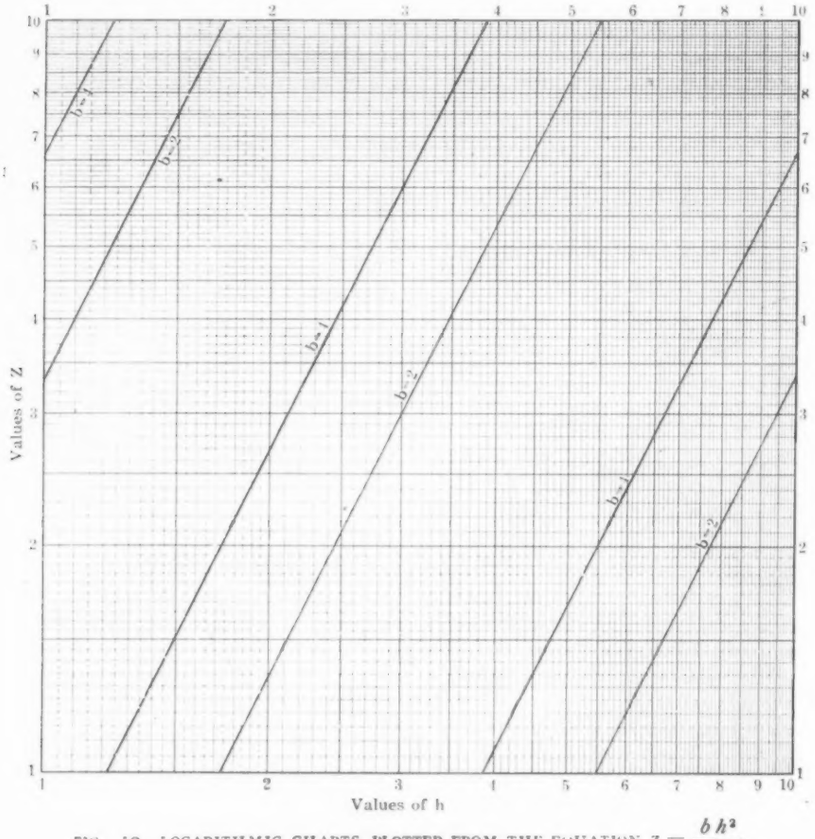


FIG. 10. LOGARITHMIC CHARTS PLOTTED FROM THE EQUATION $Z = \frac{b\,h^2}{6}$

An Alinement Area Chart

A few days ago a man engaged in making blueprints asked me to make him a chart for calculating the areas of his prints in order to aid him in fixing his charges. As it makes a very simple problem for this purpose I will use it in this demonstration, merely remarking that the diagram furnished him differs in some particulars from the one used for illustration here, in order to better adapt it to his needs.

The formula used was

$$A = \frac{W\,L}{144},$$

in which A is the area in square feet, W the width in inches and L the length in inches.

Write this in its logarithmic form

$$log.\ W + log.\ L = log.\ A + log.\ 144.$$

Let us plot $log.\ W$ on the $A\,u$ axis, $log.\ L$ on the $B\,v$ axis and $log.\ A$ on the support.

We must first decide upon the scales by which these lengths are to be measured on their axes. For instance, u, the measured length of $log.\ W$ on the $A\,u$ axis, is obtained by multiplying $log.\ W$ by some "modulus" or coefficient to get the desired length in inches. Let us call this modulus l_1 for the $A\,u$ axis, l_2 for the $B\,v$ axis and l_3 for the support.

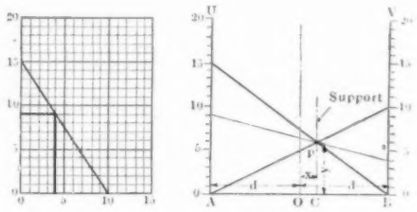


FIG. 11. COMPARISON OF A RECTANGULAR AND ALINEMENT CHART

Then

$$u = l_1\ log.\ W,$$

$$v = l_2\ log.\ L,$$

and

$$log.\ W = \frac{u}{l_1},$$

$$log.\ L = \frac{v}{l_2}.$$

Calling $log.\ A + log.\ 144 = c$, we have

$$\frac{u}{l_1} + \frac{v}{l_2} = c,$$

or

$$l_2\,u + l_1\,v = l_1\,l_2\,c$$

From equation (8) we have

$$x = d\,\frac{b-a}{b+a} = d\,\frac{l_1 - l_2}{l_1 + l_2},$$

from which

$$\frac{l_1}{l_2} = \frac{d+x}{d-x} = \frac{CA}{CB}, \qquad (9)$$

thus locating the support.

From the equation (7) we see that

$$y = \frac{l_1\,l_2\,c}{l_2 + l_1},$$

c must therefore be multiplied by

$$\frac{l_1\,l_2}{l_2 + l_1}$$

in order to give the measured lengths along the third axis, or support, and this quantity must be its modulus, or

$$l_3 = \frac{l_1\,l_2}{l_1 + l_2}. \qquad (10)$$

The graduated lengths along the different axes may be anything we chose to

make them. In general, they should be about equal and as long as possible while keeping the size of the chart within reasonable limits. The largest size of print which was called for in this problem was 40x60 inches. The logarithm of 40 is 1.602, and of 60 is 1.778. These numbers are so nearly equal that it will not pay us to use different scales in laying them out in order to represent them by exactly equal lengths on the axes, and l_1 will accordingly be made equal to l_2.

The best scale to use for a practical problem would probably be 1 inch for a logarithmic value of 0.1, thus making the length of the longest axis about 18 inches. In the drawing made for this article the twentieth scale was used, giving a chart half this size. This does not refer to the cut which, of course, has been reduced.

Since l_1 and l_2 are to be equal, equation (9) shows that the distances CA and CB are equal, or the support must be midway between the outside axes. For the modulus on the third axis we have from equation (10)

$$l_3 = \frac{l_1\, l_2}{l_1 + l_2} = \frac{l_1}{2}$$

or we must use a scale of fortieths on the middle axis, on which the areas are plotted, if we use twentieths on the outside axes. The distance between the outside axes may be anything we wish. If the axes are too close we get a compact chart, but the intersection of the index line with the axes may, in some positions, be so acute as to make accurate reading difficult. The farther the axes are apart the better this condition will be, but we must not make the distance so great as to get a chart which will be awkward to handle.

Perhaps the best arrangement for average conditions will be to have the chart about square, in which case the index line will never make a smaller angle with the axes than 45 degrees; this is not objectionable.

The two outside axes are now to be graduated so as to represent the logarithms of the desired lengths and widths expressed in inches. Start with 1 inch (whose logarithm is 0) on the AB line. On the middle axis instead of putting 1 on the AB line we must remember that logarithm A is to be added to logarithm 144 (which is 2.158), and we therefore run up 21.58 measured with the fortieth scale before beginning to graduate. Calling this point 1, we lay off from it the logarithms of 2, 3, 4, etc., and such subdivisions of them as may be necessary, till we reach 17, a trifle beyond the limits of our other scales. The chart is now complete with the exception of the lettering.

To read it, lay a straight-edge or draw a fine thread tightly across the chart so as to join the points representing the length and width of the print, and the intersection of the line with the middle axis will give the area in square feet. Better, perhaps, than either the straight-edge or thread is a piece of glass or thin celluloid with a straight line scratched on its under surface.

Such charts as this will ordinarily show a very marked advantage over those previously described. They are usually much simpler to construct, and they avoid the confusing tangle of lines so often found with the rectangular type. Moreover, since we do not have to draw a separate line for each value of the variable as is sometimes necessary with the other form, it will be easier to get close readings.

The scope of this chart might have been somewhat enlarged, without much trouble, had it been thought desirable. The prices corresponding to the different areas might have been marked on the other side of the area line in something the same manner as was done in Fig. 1. Also the chart might have been extended to give the total area or price of a number of prints of given size. To do this we should merely have to consider the area line as the outside axis of a new diagram, the other outside axis being graduated to represent any desired number of prints, and the product would be read off on a new intermediate axis. The AB, or base, line need not have been left on the chart, as it is of no use after the construction is once made, and it will generally be omitted.

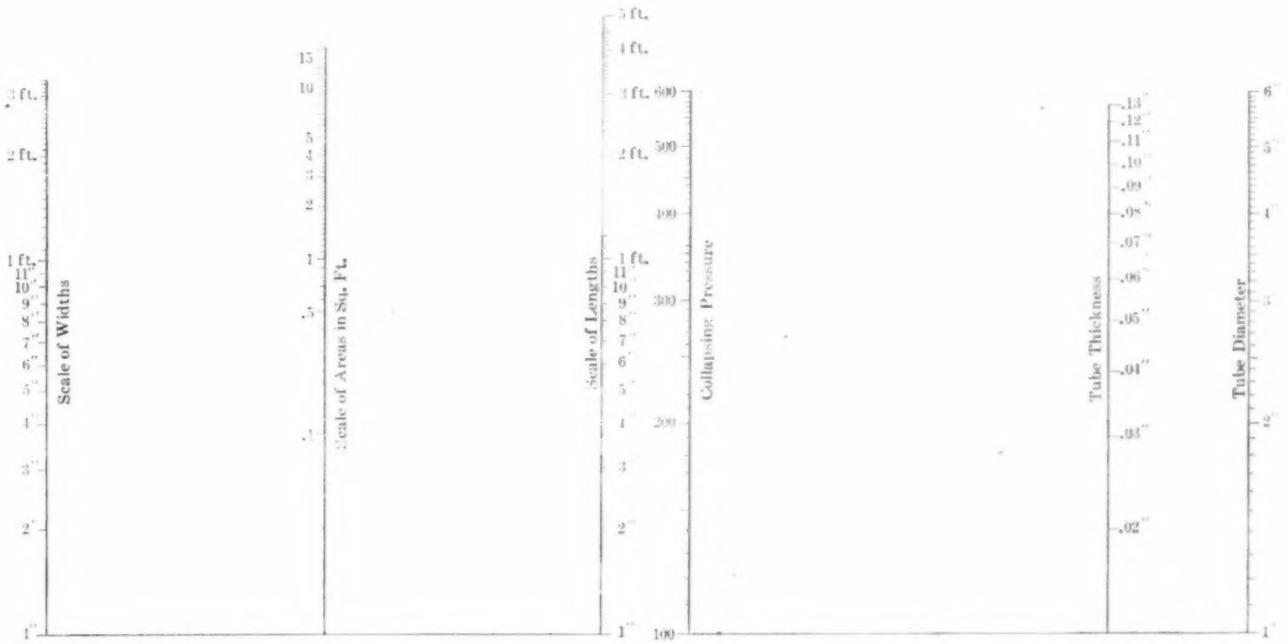


FIG. 12. ALINEMENT CHART FOR AREAS

FIG. 13. ALINEMENT CHART FOR STEWART'S FORMULA FOR COLLAPSING PRESSURES OF BESSEMER TUBING

CHART FOR COLLAPSING PRESSURE OF TUBING

Another formula charted on this plan is shown in Fig. 13. It is

$$P = 50{,}210{,}000 \left(\frac{t}{D}\right)^3,$$

and will be recognized as Stewart's formula for the collapsing pressure for bessemer-steel tubing, to be applied to pressures not exceeding 581 pounds or to values of $\frac{t}{D}$ not exceeding 0.023.

In it P is the external pressure in pounds per square inch, t the thickness of the tube in inches and D the external diameter of the tube, also in inches. It is very similar to the case we have just worked out, but there are one or two practical points in which they differ which

will make it worth our while to hastily run through the construction.

The formula may also be written

$$P\,D^3 = 50{,}210{,}000t^3$$

or

$$log.P + 3\ log.D = log.\ 50{,}210{,}000 + 3\ log.t$$

Its essential similarity with our fundamental equation will be readily seen.

Suppose we take the range in tube diameters from 1 inch to 6 inches, and let our pressures vary from 100 pounds to 600 pounds, the latter a trifle above the 581 pounds for which the formula is supposed correct. *Log.* 1 is 0 and *log.* 6 is 0.778; *log.* 100 is 2 and *log.* 600 is 2.778. This gives us a range of 0.778 in the value of the logarithm in each case. Let us make the length of line corresponding to this range the same on the two outside axes, say 7.78 divisions on whatever scale may be convenient.

On account of this equality we may write

$$l_1\ (log.\ P - 2) = 3\ l_2\ log.\ D$$

or

$$l_1 = 3\ l_2 \text{ and } l_2 = \frac{l_1}{3}.$$

Then $l_1\ (log.\ P - 2) = l_1\ log.\ D$, showing that the two scales are identical so far as graduation is concerned.

The logarithms of the values of D will be laid off from the horizontal-base line; the logarithms of P, *above 100*, from the same line. But it must be remembered that the real zero for the P-line is 20 divisions (on the scale we have chosen) below the base line, and that consequently the line corresponding to $A\,B$ of Fig. 11 will slope up from this point to the point marked 1 inch on the D-line. There is no need to draw it, however.

The location of the t-line is given by

$$\frac{l_1}{l_2} = \frac{C\,A}{C\,B} = \frac{3}{1}.$$

Next let us determine the modulus l_3 for the support or axis for t. According to equation (10)

$$l_3 = \frac{l_1\ l_2}{l_1 + l_2} = \frac{l_1}{4}.$$

Inasmuch, however, as the *log.* t is multiplied by 3 it will be convenient to consider its modulus as $\frac{3}{4}\,l_1$. The other quantity *log.* 50,210,000 laid off on this axis will, however, only be affected by the modulus $\frac{1}{4}\,l_1$.

In graduating the t-line note that we must add *log.* 50,210,000 or 7.7007 to *log.* t, and that the zero from which the graduations are measured must be on the sloping $A\,B$-line referred to above. If the left-hand end of the line, corresponding to point A is 20 divisions below the horizontal-base line, the zero for the t-line will be 5 of these same divisions below. Now, using a scale one-fourth the size of that used on the outside axes (since $l_3 = \frac{1}{4}\,l_1$) lay up 77.007 divisions. This will give us the point corresponding to 1 inch on the t-line. Our values for t, being less than 1, will all fall below this.

For example, take $t = 0.1$ inch; *log.* $t = -1$. This will be measured down from point 1 on the t-axis, the length being 30 divisions on the one-fourth scale or 10 divisions on the three-fourths scale; or, what is the same thing, we may go up 47.007 divisions from the zero. The other points on this axis may be located in the same way or by joining up suitable points on the outside axes. The chart now needs only to be lettered to be complete.

A simple modification of the alinement chart as already described is sometimes of value.

Let our general equation have the form $au + bv = O$.

In this equation c has been made zero, and, since this is so, y in equation (7) is also zero. This shows that the support for the points of intersection is now the line $A\,B$. In order to have the points of intersection lie between the points A and B it will be necessary that Au and Bv axes lie on opposite sides of the line $A\,B$. As indicated in the last example there is no necessity that $A\,B$ should lie perpendicular to the axes, and it will evidently be to our advantage to make it sloping, since in this way the chart can be made to occupy less room.

Alinement Chart for Twisting Moment of a Shaft

The methods followed in constructing this diagram will be shown by working out another practical example. For this purpose let us take the equation for the twisting moment in a cylindrical shaft

$$M = 0.196\,D^3 f,$$

or

$$-0.196D^3 f + M = O,$$

where M is the twisting moment, D the diameter of the shaft in inches and f the fiber stress in pounds per square inch.

Let

$$u = -\,l_1 f \text{ and } v = l_2 M,$$

then

$$f = \frac{u}{-\,l_1} \text{ and } M = \frac{v}{l_2},$$

and

$$\frac{0.196\,D^3\,u}{l_1} + \frac{v}{l_2} = O$$

or

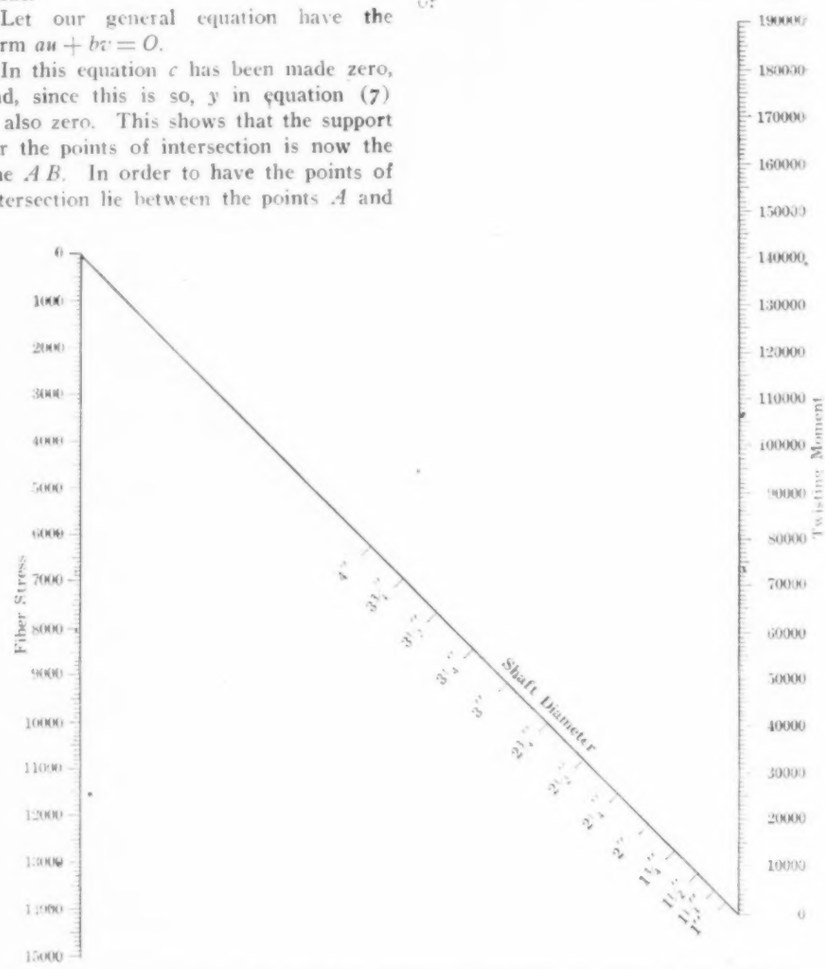


FIG. 14. ALINEMENT CHART FOR THE TWISTING MOMENT IN CYLINDRICAL SHAFTS

$$0.196D^3 l_2 u + l_1 v = O$$

Now from equation (8)

$$x = d\,\frac{b - a}{b + a} = d\,\frac{l_1 - 0.196\,D^3\,l_2}{l_1 + 0.196\,D^3\,l_2}. \qquad (11)$$

This is the equation for graduating the support. The two axes must be graduated according to the equations $u = -\,l_1 f$, and $v = l_2 M$, which show that the divisions on each axis are to be equal among themselves, or that the graduation is regular. Let us assume that the greatest fiber stress we shall need is 15,000 pounds and that our largest shaft will be 4 inches in diameter. Our maximum moment will

then be about 188,200. If we make 1 inch equal to 1000 pounds on the f-axis, this axis will have to be 15 inches long. Making 1 inch equal to 10,000 pounds on the moment axis will give us a length of about 19 inches; l_1 will, therefore, equal 10 l_2. Suppose we say that 20 inches will be a convenient length for the diagonal, then d will equal 10 inches.

Now graduate the outside axes into inches and tenths, taking as the zero point on each the intersection of the axis and the diagonal. The graduations for the D-axis or diagonal will be determined by solving our equation for x. Let us find the point corresponding to the 4-inch diameter. From equation (11)

$$x = 10\,\frac{10 - 0.196 \times 64 \times 1}{10 + 0.196 \times 64 \times 1} = -1.11.$$

The division mark for the 4-inch diameter will, therefore, be placed 1.11 inches to the left of the middle of the diagonal. As many other points as may be considered necessary are found and laid off in the same manner. In Fig. 14 this has been done for every quarter inch from 1 inch to 4 inches. To save work, the graduations on the fiber stress line need not have been extended below, say, 8000, while the diameter line might have been stopped at 4 inches.

Many other forms of equation may be easily handled by the alinement chart. Those containing variables of higher powers than the first will often require a curved- instead of straight-line support; in fact, all the axes may be curved.

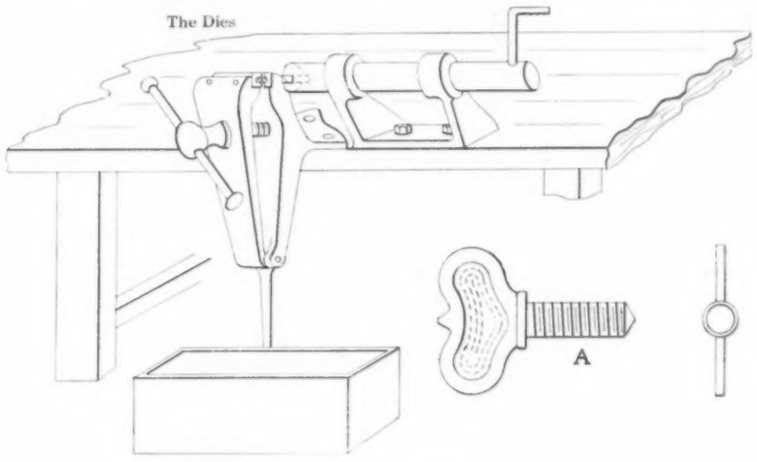
In all these charts it will be well to calculate the results for a few different conditions, and then run out the same quantities in the chart as a check. Mistakes are easily made by anyone unfamiliar with the work, and this is the quickest way to detect them.

There is no pretense that the form or arrangement of the charts presented here are in all cases the best which could be chosen. They have been selected on account of their availability as illustrations of certain points which I wished to emphasize. It should be remembered also in connection with any discussion of the size of the chart that the cuts used here are reductions from the original drawings, and that in general, it is desirable to have the charts as large as convenience in handling will permit. A great variety of other forms and applications of the graphical chart are known and have been used. What I have given here is only the barest outline of a few which I thought would have the greatest practical interest for the readers of this periodical.

A Homemade Tapping Machine

By A. J. Baker

Sometimes it happens that the homemade machine of the little man knocks large chunks of conceit from the carefully designed product of the up-to-date factory. Here is a case in point:



THE HOME-MADE MACHINE

Not many American readers of the American Machinist are familiar with the "Black Country" of England. It is the coal-bearing tract of the midland counties. Scattered about the district are a number of small towns, where all sorts of hardware are made in all sorts and conditions of shops. A large proportion of these shops are small, under-capitalized and under-staffed, employing the cheapest labor and using the most primitive tools. One can easily see, therefore, that the seller of machine tools does not have the easiest time disposing of his goods.

A certain shop made large quantities of brass thumb screws. These screws—shown at A—were cast to size, dressed on a disk grinder and then threaded. The owner of the shop, a progressive man, viewing the tools used for the latter process, conceived the idea that a more modern machine would effect economy. The result was that quotations and guaranteed time for threading the screws were received from several machine-tool makers.

The type of machine to be supplied was a horizontal tapping machine with a spindle (carrying the solid die) which ran in a sleeve driven either way, according to which pulley was in engagement with the clutch. The clutch was operated by the longitudinal movement of the spindle; a stop was provided against which the work holder struck, so pulling the spindle outward and thereby releasing the clutch.

So far, so good; but it was found that the best guaranteed time was more than twice that consumed by the old method, wherefore much confabulation ending in a visit from the representative of the concern that promised best.

I happened to be the representative, with my brain full of details as to time for chucking, fastest threading speed, fastest reverse, quick gripping fixture, etc. I was cheerfully accosted by the proprietor of the shop, who said: "Not only is your machine too slow, but its cost is excessive. Why, I could make three machines for the thirty dollars you want for that one."

I replied, "There's nothing on the market—"

"Come and see," said the proprietor.

I went, I saw, and was conquered—and by this:

An ordinary leg vise of the type generally used in England—a short wooden handle replacing the customary steel article. Attached to either jaw was the half of a tool-steel block that had been tapped, sawn in two and hardened to make the dies. On the bench at the side of the vise was a cast-iron bracket with a hole bored to receive a loosely fitting steel bar, the front end of the bar slotted to act as a driver on the thumb-screw head. A bent handle stuck in the rear end of the bar. No more, no less. No belts, clutches, fixtures, and the working of it was beautiful.

The girl operator picked up a thumb-screw casting in her right hand and placed it against the half die attached to the fixed jaw of the vise. With her left hand she closed the loose jaw onto the screw. The right hand brought the slot on the end of the bar into engagement with the thumb-screw head. Six turns forward of the bar, six turns backward, simultaneous release of the left hand, the screw falls down into the basket below, finished. Time, five seconds.

The line cut shows the general arrangement. No sketch could show the look on my face; there was nothing to be said, and I said it.

Another point in which the primitive arrangement scored was in the elasticity displayed. If a casting was large, a few more turns were required and the piece brought to size. With the solid die on the orthodox arrangement, a large casting would have meant a broken casting and a stopped machine.

Difficult Metal Core-box Work

Best Materials to Use, Special Cutters, Files, Scrapers, Chisels, Etc. Used. Also Special Chucks and Appliances Used on the Machines

BY ETHAN VIALL AND J. J. VOELCKER

Little has been written on the subject of core boxes or core-box making, and at the mention of the word, most of us conjure up visions of clumsy wooden affairs that we have seen stacked up in the out-of-the-way corners of some foundry.

It is in the brass or soft-metal line that the core box has reached its greatest state of perfection, and few outside the shops turning out this class of goods ever see or hear of the complicated core boxes used. Some of the more complicated forms call for the highest mechanical skill of the metal pattern-maker.

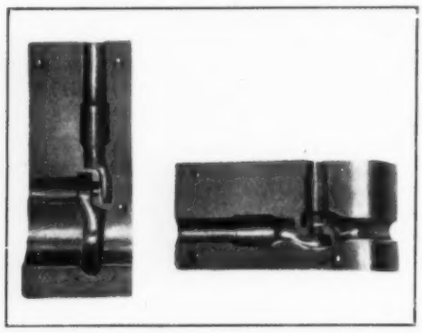


FIG. 1. FORGED CORE BOX

The making of metal core boxes used for producing cores for cock and valve bodies used in the regular plumbing-goods line, is a trade by itself and classes with die-work and is considerably above the ordinary run of die-sinking used in drop-forge work. The illustrations accompanying this article were taken at random from the hundreds of subjects to be found in a large manufactory, and by no means do they show the most difficult jobs turned out here.

In the manufacture of brass goods such as gas and water cocks, valves and the various fittings used in the plumbing trades, the cavity plays a very important part in the ultimate cost of the goods. If the cavity is smaller than necessary, too much metal is used, and at the price of brass it would soon mount up into money, as the saying is. On the other hand, a cavity that was too large would weaken the fittings and cause loss of goods and reputation.

Accuracy in Cores

Taking these items into consideration, one will at once see the importance of having the cavity of the correct size and proportion, and as the cavity is produced by introducing into the mold a form which is produced by pressing a mixture of sand, flour and oil into a core box and then baking the form produced in a special oven, then the care with which this core box must be made will be fully realized.

Originally, many core boxes were made of wood, but for very many reasons this is not advisable where any number of cores are required.

Cast iron is also unsuitable for several reasons where accurate, durable work is required. For some work steel castings are used, but this metal is far from uniform and porous spots or blow holes would be sure to show where least desired or expected, many times completely ruining the box or necessitating the insertion of a piece.

For this reason hammered slab steel, which can be case-hardened after the core box is finished, makes a much better job, and it is almost indestructible. The use of slab steel is expensive in some ways, as the slabs must be cut into suitable pieces and shaped up. Two of these pieces are usually fitted together with dowel pins, and the core shape worked out of them, one-half being worked out of each piece.

The uniformity of grain, ease of cutting, and the absolute certainty of not being compelled to patch up a porous place make it by far the best material to use, but it is the most expensive to work. A good power hack saw and other suitable machinery will, however, reduce this cost considerably.

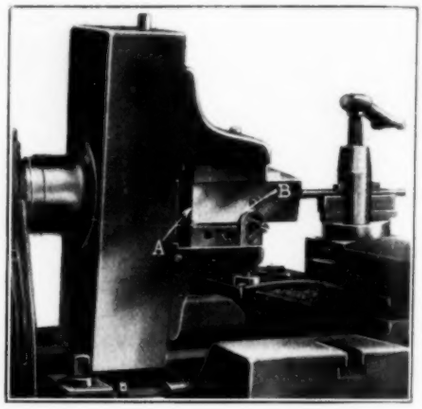


FIG. 2. SPECIAL TWO-JAWED CHUCK

Brass is used to a very large extent in making metal core boxes and patterns as well, as it wears well, although the corners are more liable to round off than when steel is used. It is much easier to work than steel, and does not rust. The latter is quite an important item, as foundries and core rooms are very damp owing to the water used in the molding sands and the steam generated when castings are poured. The easier working properties are also important owing to the high-priced labor

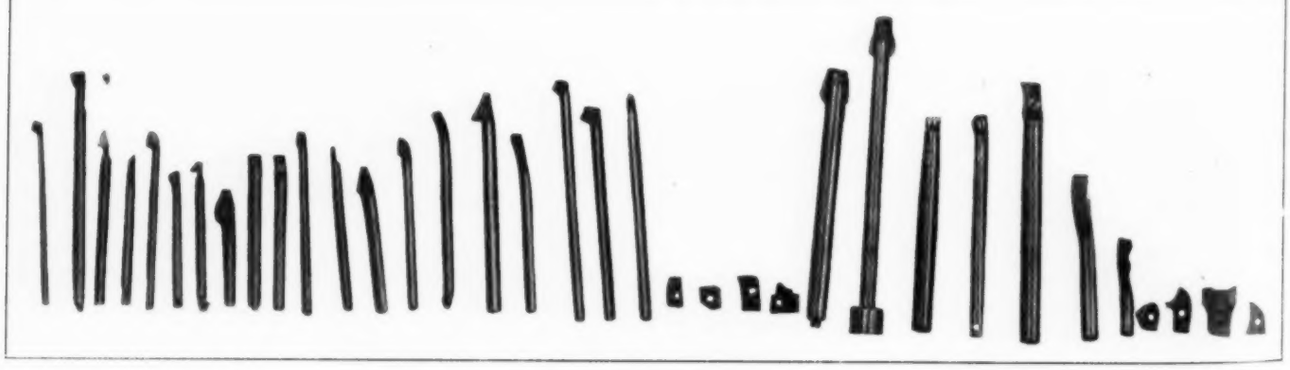


FIG. 3. SPECIAL TOOLS FOR CUTTING THE CORE SHAPES

used in making metal core boxes and patterns.

Occasionally a core box is forged of machinery steel, as shown by Fig. 1.

In order to avoid trouble and confusion in the use of dowel pins certain standard sizes are used. These pins are made in two styles and several sizes, and the blueprints always specify the kind to use. A dowel-pin chart showing these styles and sizes is hung in the metal patternmakers' room in a convenient place for ready reference. The various kinds of pins are made up in quantities and are always kept on hand.

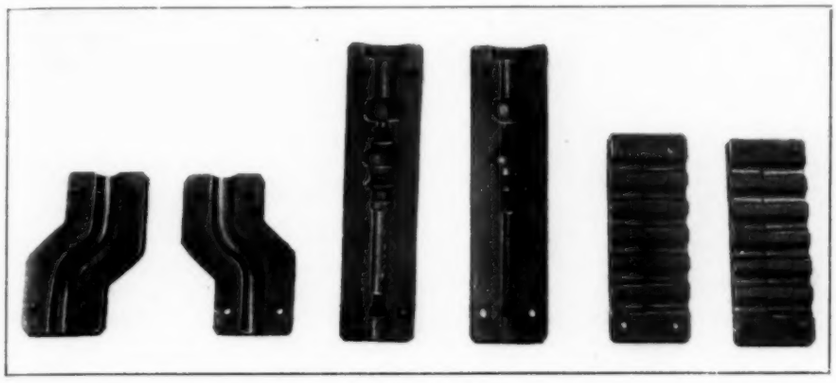


FIG. 4. MULTIPLE AND WATER WAY CORE BOXES

Laying Out the Core Line

After the two halves of the piece intended for a core box have been fitted together, the next step is to lay out the outline for the core which it is intended to form. To do this the pieces are separated, the inside surface of one of them is coppered and the outline laid out and scribed from the blueprint. The pieces are then put together and the circumferences of the holes to be bored are scribed on the edges of the blank, which has previously been coppered in the same way as the inside face.

Formerly the holes were bored by clamping the blank on an angle plate bolted to the face plate of the lathe. Then the work was trued up from a punch mark representing the center of the scribed circles, an ordinary "niggle stick" being used for this purpose. Now, however, two-jawed lathe chucks of special design, as shown by Fig. 2, are used. These are made in the shop and make it necessary to true the work up sideways only. A raised rib *A* on the false jaw of this chuck squares the blank and the jaws true it up and down.

A stop *B* fastened to one jaw of the chuck, is set wherever required. This arrangement permits the work to be taken out and inspected as often as desired and then replaced without changing its position. This last is very important, as in many boxes the cavity is so small that the work must be removed and taken apart to clean out the chips which otherwise they might clog the tool and tear the metal.

The Making of Cutters

Many special shapes of boring and forming tools are used in cutting out the core shape. These are usually forged from drill rod and some of the forged tools that have been used are shown in the left-hand half of Fig. 3. Some tools with inserted cutters as well as extra cutters are shown in the right-hand half of Fig. 3.

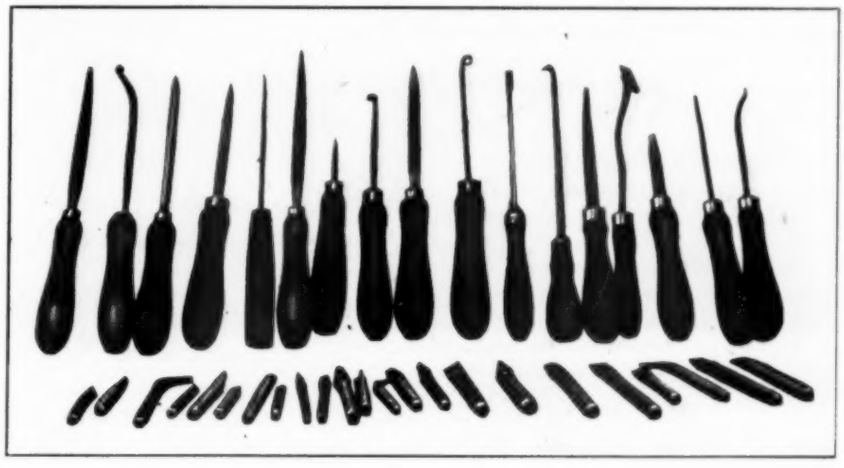


FIG. 7. SOME ODD SHAPES GIVEN HAND TOOLS

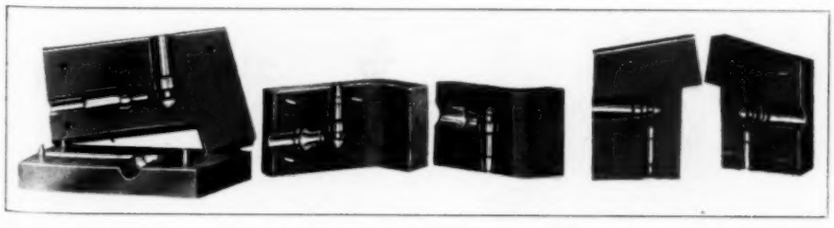


FIG. 5. COMPRESSION COCK BODY CORE BOX

FIG. 6. REAMERS USED FOR CUTTING CORE BOXES IN FIG. 5

The cutters are made of flat steel which is filed to shape and the gear holes drilled in them; they are then hardened and tempered and screwed onto cold-rolled rods of suitable shape and length. The longest tool in this cut is an end-forming reamer and the two tools next to the cutters on the right are jointed tools which are used to work out a large cavity through a small opening.

On some kinds of core boxes a templet is made of sheet steel which has one edge shaped like the outline of one-half of the core. This templet is fastened to the taper attachment of the lathe and by keeping a guide on the cross slide against this the hole is bored out the desired shape.

Self-hardening steel is used for special shaped tools wherever possible. Small pieces of various sizes are kept on hand

and ground to the shape wanted and a number of different shaped holders are kept for shop use.

Most of the work on the inside of these boxes is done without the operator being able to see the cutting edge of his tool, therefore positive, adjustable stops must be used to limit the movement of the lathe carriage along the bed.

Sometimes in long boxes with a comparatively small cavity a 90-degree tool is used in the shaper and a long groove planed in the two halves as a guide for the drill which is run in to make an opening for the boring tool.

Special Cutting Tools

For simple cores, multiple boxes are made, sometimes as many as six or eight cavities of the same size and shape being placed in the same core box. One of these in its simplest form is shown to the right of Fig. 4. It is quite a nice little job to work out the cavities for waterway cores for water fixtures, as shown on the left of Fig. 4, and in some shops they are made in sections, but here they are worked out of the solid block. Some of these cavities are partly cut or finished with cutters made for the purpose.

FIG. 8. EXTRA LONG CUTTERS

In Fig. 5 is shown three styles of core boxes for making cores for what are known as compression-cock bodies. These cavities have been cut with special cutters similar to those shown in Fig. 6. They are made by turning a bar of steel to the exact size and shape that the core is to be, after which they are fluted, hardened and tempered. As a usual thing these cutters are used in the lathe, though whenever possible to spare a milling machine they are used in that.

The cutter is held in the chuck and one-half of the blank is clamped to the cross-slide and fed against it.

A collar, held by a set-screw, fitting over the reamer shank acts as a guide endwise, and the collar can have a center line marked on it to indicate when the half core box has been cut to one-half the depth that the core is to be. The blank has previously been bored out to the straight sizes of the cutter and these bores steady the cutter and act as a stop when the right depth is reached.

After the two halves of the core box have been cut out in this way, they are put together on the cutter and clamped and the cutter revolved, the clamp being gradually tightened until the two halves of the core box are tight together. This insures a cavity the size of the cutter. The rest of the cavity is chipped, filed and scraped out and is a slow, tedious job of hand work. Fig. 7 shows a few of the odd shapes which have to be given chisels, files and scrapers used for this hand work on the different kinds of core boxes.

Extra Long Core Boxes

Cutters which are used for making core boxes in which the cavities are extremely long and inacessible to boring tools, are shown in Fig. 8. The middle box in Fig. 4 is a good example of one of these.

The cutters used on these boxes are rather difficult to make owing to their irregular form and springy nature. After milling they are relieved by hand and it is a tedious job to get them straight after hardening.

In making a core box containing a long square, taper hole, the average mechanic falls down on his first attempt by cutting away too much metal. The best way is to bore a taper hole of the diameter of the side of the square desired and then set the shaper platen, using this hole as a guide. The cutting is done with a 90-degree tool.

This is a kink worth remembering for we notice almost every new man scratch his head long and hard over the job.

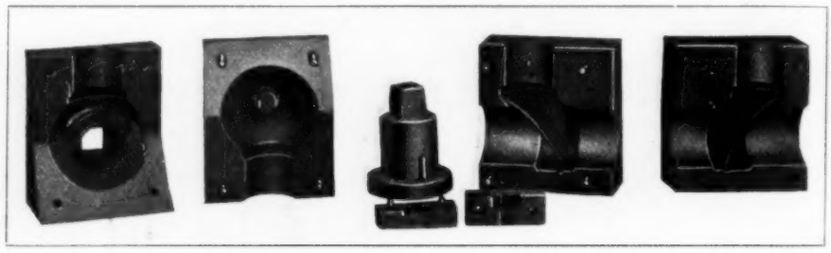


FIG. 10. GLOBE CHECK-VALVE CORE BOX

FIG. 11. SPECIAL RIG FOR MACHINING CORE BOXES

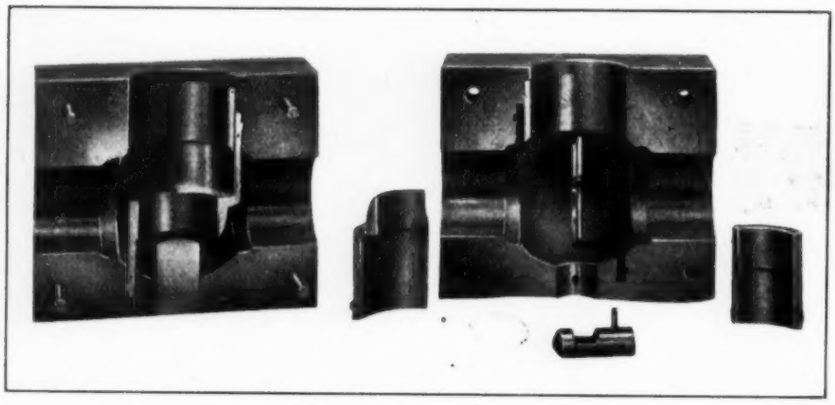


FIG. 9. GLOBE CHECK-VALVE CORE BOX

S-pipe and Check-valve Cores

On the left of Fig. 4 is shown a box for an offset-coupling core shaped something like the letter S. This is another puzzle to the green hand, but it is very simple. A hemispherical cavity is bored

just where the two curves meet, its diameter being the same as that of the ends of the hole and its depth one-half of this. One-half of the blank is then clamped onto the face-plate and the curved cavity worked out, the face-plate being worked back and forth by means of a lever bolted to it, as in Fig. 13. In this cut, however, another kind of box is being worked out, the box shown being clamped sideways. The most difficult job of core-box making in the valve shop is for the cores used in the globe valves, and this work naturally requires the services of the most skilled metal pattern-maker. Two different kinds of this style of box are shown in Figs. 9 and 10. The core box shown in Fig. 9 has three loose pieces. The half-box to the left of the half-tone shows the box assembled ready to ram the core sand in, while the half box to the right shows the loose pieces out of the box. The loose pieces to the right and left of the box must be given the proper draft so they can be drawn out of the box after the sand has been rammed in, and these cannot be given a straight lift, but must follow the circle they form in the sand. Thus if they were both drawn at the same time they would form a complete circle and come together again above the box. The loose piece lying under the box merely forms a boss inside of the valve and lifts straight up from the core. This makes it necessary to have the loose pieces a perfect fit and thinner at the bottom of the box than at the top with a gradual taper from one to the other.

Sometimes only one-half of the box is made for this kind of a core and two half cores are made in it after which they are pasted together.

Ingenious Rig for Milling

The style of check-valve core box shown in Fig. 10, is made in three parts, and the

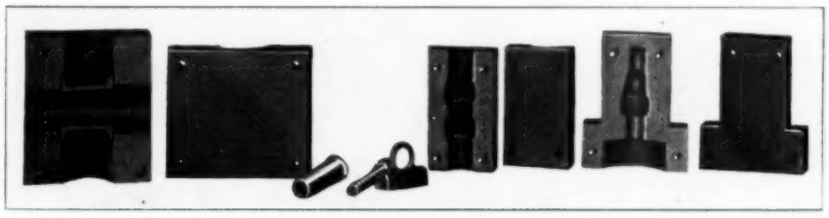


FIG. 12. SMALL CORE BOXES

part at the right-hand of the cut is a difficult piece of work. This was at first a puzzle, but Anton Schuermann, foreman of the metal pattern-making department, designed the tools, shown in Fig. 11, to cut the irregular shaped cavity in the center of the box.

In doing this one-half the box is clamped to the face plate of the lathe at the desired angle; a cutter of the right size is placed on the holder, which is clamped in the tool post. A rod is inserted in the hole shown in the cutter at the extreme right of Fig. 11, and the cutter is then worked back and forth by means of the rod and fed in by the carriage. The teeth of these cutters are formed so that they will cut both ways.

The three small pieces, shown in the center of Fig. 12 are the parts of a core box for making small cylindrical cores. The piece to the left of these is the core box, the center piece is a plunger and the

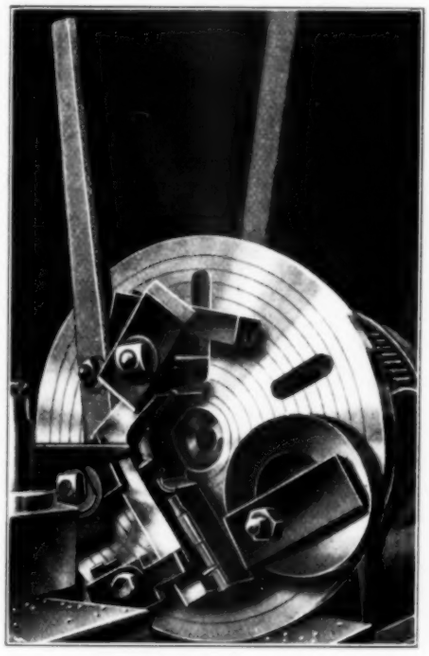


FIG. 13. CORE BOX CLAMPED ON FACE PLATE

piece to the right is a spacer. To make a core, the end of the plunger is inserted in the hole of the core box with the spacer between the end of this and the shoulder of the plunger. The whole is then held in one hand and sand rammed into the box, the spacer drawn away with one finger, and the plunger pressed down with the thumb, thus forcing the core out. Different sized spacers can be used to make various lengths of cores.

A Basin-cock Core Box

The forged core-box blank, shown in Fig. 1, is for a basin cock having its handle at the side instead of the top. This is another difficult job when it comes to cutting the biff or curved part of the spout end.

The middle piece in Fig. 5 shows this box after it had been milled with special cutters, shown in Fig. 6, and Fig. 13 shows the concave half of the box is clamped to the face-plate while the biff end is being worked out. This curved cavity is also tapered, which variation has to be controlled by judicious use of the cross slide and by shifting the position of the work on the face-plate.

As an example of the time taken on one of these jobs, the time for making the drawing for this box was four hours, forging, planing, and fitting, 14 hours, and the lathe and hand work 51 hours, making a total of 69 hours at an average cost for labor of 40 cents per hour. Some of the work was done by the 30- or 35-cent men, while the more particular work was done by men getting 40 or 45 cents.

Had this box been made by inexperienced men the time would have been doubled at least and a poorer job been the result.

Conclusions

Many of the simple core boxes only require from two to four hours' work after the parts are fitted and doweled, while others require 90 or 100 hours, or even several weeks.

There are thousands of core boxes used in this plant and 60 core girls are constantly employed making cores. In the metal-pattern shop five men are kept busy on core-box work all the time and sometimes more.

Sample castings are sawed up after a new core is used to make sure that the metal is of the correct thickness in all of its parts; if not, the core box goes back to the metal-pattern shop with sketches and instructions to alter where needed.

When not in use the core boxes are stored in an immense fire-proof vault, as their loss would not only mean a large expense, but cause considerable delay in production.

The first of the German "Dreadnoughts" was put into the water early in March. The principal point of interest in connection with this vessel was the report that she was to carry sixteen 11-inch guns in six turrets, four of which were to carry three guns each, and that the arrangement permitted all of these guns to be trained on one broadside. It now appears that the six turrets will carry two guns each, or twelve in all. The location of turrets is unique, there being two forward and two aft, the inner one in each case being higher than its mate, and firing over it. The other two turrets are arranged amidships, one on each side, but one forward of the other. Both can thus be trained on either side.

The Bower-Barff finish is produced, according to the *Brass World*, by heating iron or steel for several hours at a red heat in a closed muffle filled with steam. A magnetic oxide of iron is formed on the surface, and forms a black, durable coating. Genuine Bower-Barff finish can be applied only to iron or steel.

Practical Letters From Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

Some Failures and Successes in Press Punch Work

The accompanying line cuts show how a job which when done singly in the press seemed doomed to be a failure, was made a success by doing it two at once. Done singly the profits were almost nil, made two at a time it earned a respectable dividend.

The article referred to is shown in Fig. 1 in plan and elevation, and also the blank from which it was made. The stock was cold-rolled steel, 0.072 inch thick, and the product had to be fairly uniform.

The job, to the office people, looked a simple forming job and sketches, came down for a pair of tools to raise the job in the manner shown by Fig. 2. Inspection will show that the blank will be first struck by a very small part of the punch which is convex and consequently the blank may be expected to slip. This is precisely what did happen. The product therefore was not uniform. A spring plunger was then suggested, tried and found wanting. *A* is the punch, *B* the blank, and *C* the die.

A new pair of tools was then designed, after the manner shown by Fig. 3. These, however, were not made, for the following reasons: The foreman of the press department, who chanced to see the drawing, said that on light stock it would probably work out all right, but that, on the steel stock required, he would need so great a tension on the plunger *D* that he would not have power enough to do the job.

"Besides," said he, "a better way would be to do them two at once and then part them." This, to the office people seemed very funny, as they had visions of jigs, milling machines, etc.

After a consultation, it was decided to adopt his suggestions. The blanks were cut out as shown at *B*, Fig. 1, then drawn through an ordinary draw-through die, which is not shown.

No trouble was experienced this way as the articles balanced themselves and thus came out very even.

Fig. 4 shows the tools for parting the pieces. These worked very well, gave no trouble, and the principle was afterward extended to other jobs. Reference to the drawing shows: *A* is the punch, *B* is the top die or form, *C* is the lower die, *D* is the sliding member, *E* is the cam and *F* the bed or bolster. The other parts, all plainly shown, such as screws, pins, dowels, springs, etc., need no comment.

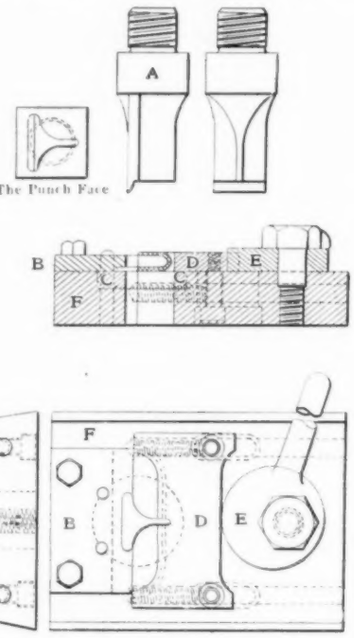


FIG. 4. THE TOOLS FINALLY USED

The tools as shown are in the closed position with a pair of the articles, shown by the dotted lines in the plan, and the heavy section in the sectional elevation, ready to be taken out.

In operating, the drawn shell is slipped on the form *B*, and slide *D* is closed up by the cam *E*, forcing the shell to its proper position and by inclosing it around its ends stopping any tendency to spread open as the punch *A* does its work.

The tools were constructed as follows: The punch was of tool steel throughout, also the top die and lower die. The slide and cam were of machinery steel case-hardened. The bed was of good quality gray iron machined all over, the two dies were fitted to it and dowelled, before being marked out for the cutting part, the top die was marked out and then drilled right through the bottom die as well; after being worked out parallel the tools were disassembled, the dies backed out slightly and then hardened and tempered.

Sheffield, England. WILFRED GEORGE.

Dip for Aluminum

Not very long ago we had some small aluminum castings for a polyphase relay. These were in the shape of a segment and were in plain view after assembling. Formerly brass ones were used, but having been successful on other small aluminum castings it was decided to try these, and the result was satisfactory. However, brass could be dipped in sulphuric acid and a finish given it, but something different was required for aluminum.

The following was finally worked out and the results were satisfying indeed, and possibly it may be of value to others.

Method: Dip in a hot bath composed of a 10-per cent. solution caustic silver saturated with common kitchen salt. Leave aluminum in bath from 15 to 20 seconds; take out, wash and brush it. Then put into bath again for about 30 seconds and wash again, drying in sawdust.

Rochester, N. Y. JOHN COAPMAN.

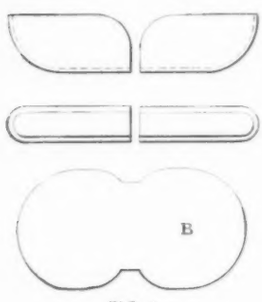


FIG. 1

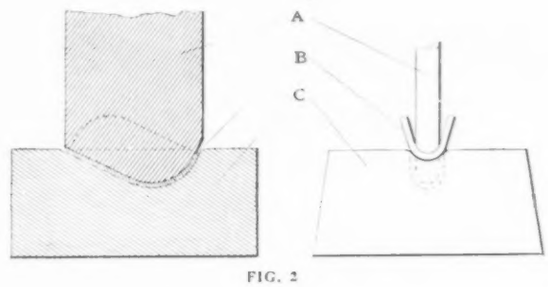


FIG. 2

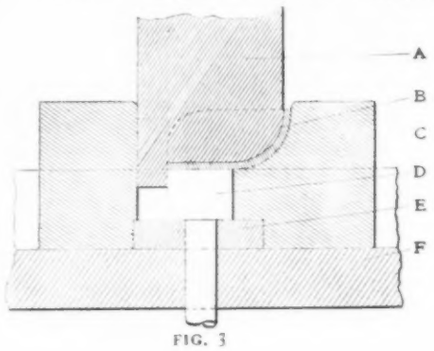


FIG. 3

THE WORK AND THE ABANDONED TOOLS

Table of Divisions Corresponding to Given Circumferential Distances

I inclose herewith a table of approximate number of divisions and distances apart on circumference, corresponding to a known diameter of work. This table is very useful in milling-machine work in cutting mills, saws, ratchets, etc. In the many books on machinery published, I have been unable to find any such table, and hope it may help out some machinists who have to figure these things out.

For example: A man gets a straddle mill, say, 5 inches in diameter, to be cut with teeth 7/16 apart. He will have to go to the trouble of multiplying the diameter by 3.1416 and then divide by 7/16 to find the number of teeth to set up for. In the table, under 7/16 and opposite 5 he can find at once the number of divisions, as 36. Where the table shows an odd number of teeth, one more or less can, of course, be taken if it is important to have even number of teeth.

New Haven, Conn. JAS. FRASER.

Dia. of Work.	Distance on Circumference.														
	1/32"	1/16"	1/8"	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"	7/8"	1"
1/8	25	12	6												
3/16	31	16	8												
1/4	38	19	9	6											
5/16	44	22	11	7	5										
3/8	50	25	13	8	6										
7/16	63	31	16	10	8	6									
1/2	75	38	19	13	9	8	6								
9/16	88	44	22	15	11	9	7	6							
5/8	100	50	25	17	13	10	8	7	6						
11/16	126	63	31	21	16	13	10	9	8	7	6				
3/4	150	75	38	25	19	15	13	11	10	8	7				
13/16	176	88	44	29	22	18	15	13	11	10	9	8	7	6	
7/8	200	100	50	34	25	20	17	14	12	11	10	9	8	7	6
15/16	226	113	56	38	28	23	19	16	14	13	11	10	9	8	7
1	251	125	63	42	31	25	21	18	16	14	12	11	10	9	8
1 1/16	277	138	69	46	35	28	23	20	17	15	14	13	12	10	9
1 1/8	302	151	75	50	38	30	25	22	19	17	15	14	13	11	9
1 3/16	327	163	82	54	41	33	27	23	20	18	16	15	14	12	10
1 1/4	352	176	88	59	44	35	30	25	22	20	18	16	15	13	11
1 5/16	378	189	94	63	47	38	31	27	24	21	19	17	16	14	12
1 3/8	402	201	100	67	50	40	34	29	25	22	20	18	17	15	13
1 7/16	428	214	107	71	53	43	36	31	27	24	21	19	18	15	13
1 1/2	454	227	114	76	57	45	38	32	28	25	23	21	19	16	14
1 9/16	478	239	119	79	60	48	40	34	30	27	24	22	20	17	15
1 5/8	503	252	126	84	63	50	42	36	31	28	25	23	21	18	16
1 11/16	528	264	132	88	66	53	44	38	33	29	26	24	22	19	16
1 1/2	554	277	138	92	69	55	46	40	35	31	27	25	23	20	17
1 13/16	579	289	145	96	73	58	48	41	36	32	28	26	24	21	18
6	604	302	151	101	76	61	50	44	38	34	30	27	25	22	19

TABLE OF NUMBER OF DIVISIONS CORRESPONDING TO GIVEN CIRCUMFERENTIAL DISTANCE.

Planing Keyways in Gears, Pulleys, etc.

The sketches illustrate clearly an economical method for cutting keyways in gears, pulleys, etc., in the shaper. The high V jaws are the only attachments required in addition to standard equipment. One set of jaws is all I have found necessary and these are suitable for quite a variety of work.

The piece that is to be splined is first put on an arbor and centrally positioned in relation to the V in the jaws by the arbor as in Fig. 1. The jaws of the vise are next brought tightly against the work and the arbor withdrawn. The splining tool is readily located centrally by the V in the jaws as shown in Fig. 2. Fig. 3 represents the work clamped with the arbor removed.

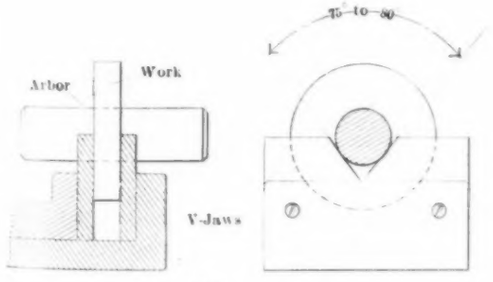


FIG. 1

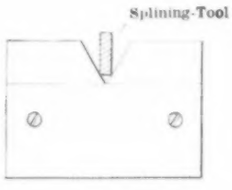


FIG. 2

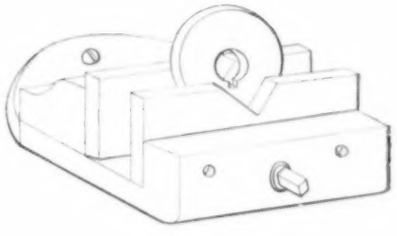


FIG. 3

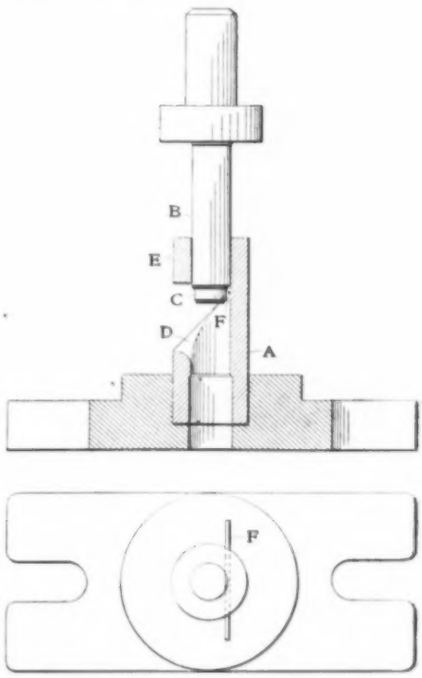
CUTTING KEYWAYS IN THE SHAPER

The splining tool does not require resetting centrally except when ground, and the facility with which the work may be correctly clamped makes this method a very desirable one where there are no special broaching machines for splining work, as the rate of production is mostly dependent upon the time required in actually planing the slot.

Hartford, Conn. C. L. GOODRICH.

Simple Ring-forming Tools

I have seen several tools and fixtures for making rings, in small quantities, cheaply, and, outside of the automatic wire-forming machine, I believe the tools here illustrated to be most effective.



A SIMPLE RING-FORMING DEVICE

They are for making rings of wire, and, where a power or foot press is available will be found cheap, and rapid in operation. One stroke of the press does the trick, and as the finished rings drop through the die, the operator can devote his entire attention to the feeding of the wires.

I have arranged the tools with gages to locate the wires previously cut, and also with the cut-off on the tools. As it is my object to illustrate the principle only, no attempt has been made to show the gages or the cut-off.

Referring to the illustration, *A* is the

tool-steel forming tube bored to the size of the outside diameter of the ring. *B* is the punch, turned to fit the tube *A* and with a pilot *C* the size of the inside diameter of the ring, and a little tapering, about ¼ degree to allow the ring to strip off easily.

The tube *A* is cut away at *D* on an angle of 45 degrees, leaving the section at *E* to hold the punch from springing out of line while forming the ring.

It will be noticed that the face *D* is gradually rounded into the hole as it approaches the lower part of the slant. The bottom of the tube is bored out to allow the rings to spring open a little and thus strip off the punch and drop through the die. *F* is the wire in position to form.

I think the operation of the tool will be readily understood. The sizes of *B* and *C* and the shaping of the face *D* are the essential features.

New Britain, Conn. B. S. FRANK.

Making a Special Nozzle

We made a steam pressure-reducing nozzle in our shop for the U. S. Naval Experimental Station at Annapolis which was to be machined as shown in Fig. 1.

We were furnished with a templet, Fig. 2, to gage the curved taper bore of the nozzle. This templet was so shaped that when the curved part *C* was in place in the nozzle the straight back *b* corresponded with the axis of the nozzle (see Fig. 1, heavy dotted lines showing templet in place).

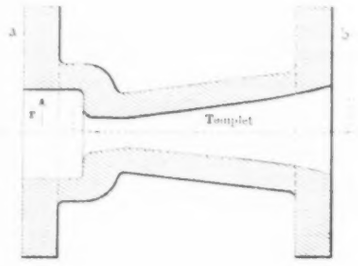


FIG. 1

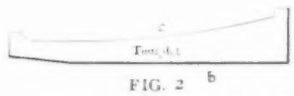


FIG. 2

THE NOZZLE AND TEMPLET

We chucked the casting in a lathe so we could work on the end *a*, Fig. 1, and turned off the outside of the flange to size and faced it. Then we bored the recess *r* to size. Then we had to turn the casting around and to save the time and trouble of truing it up, we caught a scrap cast-iron plate in the chuck and faced a recess in it about ⅛ inch deep and 8¼ inches diameter so that the flange we had turned would fit snugly into it.

When the recess was finished the casting was put in place in it and clamped. This held the work true and saved time that would otherwise have been used to true it up. After it was clamped in place the outside and end of the flange were turned off. Next we roughed out the taper hole; to get sizes for this we laid its shape out on paper by using the templet, Fig. 3, and then spaced it off into divisions 1 inch apart. We set the inside calipers to the largest of these divisions and bored the casting out to the calipers 1 inch back from the end.

We then set the calipers to the next largest division and bored the casting out to this size 2 inches back from the end. We repeated this until the casting was roughed out.

To finish the taper hole we had to make a guide bar as shown at *g*, Fig. 4, 15 inches long of 2x⅜-inch machine steel. We laid the templet on this bar and scribed its shape on it and then machined the curved part *c* to the right shape. We then made a ⅜-inch slot in each end ¾ inch long to pass a bolt through to fasten it with.

Two cast-iron blocks *b*, Fig. 4, which were intended to place between the headstock and bed of the lathe to increase its capacity, and which had V-grooves in them to correspond to the ways of the lathe bed, were clamped to the lathe bed about 13 inches apart in front of the work

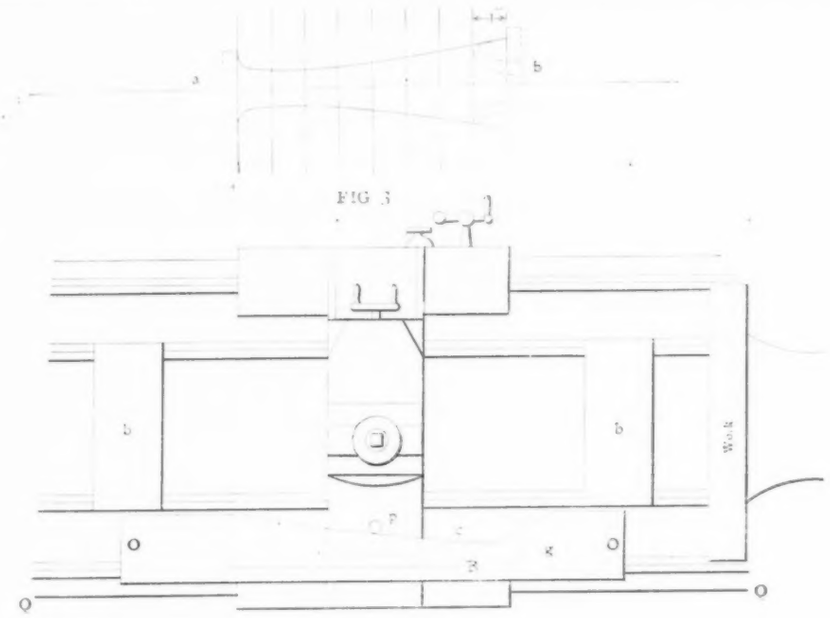


FIG. 4

HOW THE NOZZLE WAS BORED

with the carriage in between; a small right-angle bracket was clamped on each one. These brackets had ⅜-inch holes in top through which bolts were passed and the guide bar was laid on top of the brackets and the bolts were also passed through the slots in it. The guide bar was then adjusted by making the line *B*, Fig. 4, parallel to the lathe bed.

A ½-inch hole was drilled and taper reamed in the cross-slide, from which the cross-feed screw had been removed, and a pin *p* was made to fit in it which was long enough to come in contact with the surface *c* of the guide bar, and a weight was fastened to the cross-slide by means of a rope. This weight held the pin in constant contact with the guide bar.

A boring tool was placed in the toolpost using one which had an end small enough to pass through the smallest part of the hole, and it was clamped in position so it would begin to cut when the pin *p* was at the beginning of the curved part of the guide bar. Everything being now ready the carriage was placed in position for the tool to begin its cut and the lathe started. The longitudinal feed was thrown in and the hole bored to size. After the hole was finished the casting was again turned so that the end *a*, Fig. 1, was toward the right-hand end of the lathe and the edge *a* of the hole was finished up by rounding it off a lit-

tle to fit the gage. This finished the job up in good shape.

Govans, Md. F. E. FICK.

Boring and Turning Fixture for Connecting-rod Brasses

Some time since, having charge of a shop manufacturing steam engines, and after having the management inform me that such and such engines could be considered as standards, I made jigs and templets for such parts as we were apt to be called upon to replace.

The illustration shows a turret-lathe fixture for boring and turning connecting-rod brasses.

The brasses, after having been planed or milled to gage, were fitted by filing or scraping to a standard fitting fixture or gage conforming to the inner dimensions of the connecting-rod straps of the different sizes of engines. By this method we were able to duplicate all our connecting-rod brasses. Many of the engine parts were carefully and accurately made, relieving us of all anxiety when sending away repairs as to whether the parts would fit just right. This method of doing work would make the first cost of the finished parts more, but in the erecting of engines we more than squared ourselves, besides having the satisfaction of doing work the right way.

Fig. 2 is a face view of the fixture looking toward the headstock, and is made in the form of a face plate screwed upon the lathe spindle. Cast to this face plate is a cradle *A* having a hub at each side central with the spindle for spring-actuated time plugs *B* entering the swivel work-holding yoke *C*. The cradle is strongly ribbed at each side; the time plugs are pulled out to the limit and slightly turned, a pin *D* holding them out until the work yoke has been turned one-half around, when the yoke is again locked with time plugs. The yoke has a bearing at the lower end *E* as well as an overlapping cap *F* at the upper end. The cap is bolted to the yoke with swing bolts, the end of the cap having openings to permit the bolt to swing freely. On the upper part of the cap two bosses are seen; these retain a strong spring-actuated plunger that forces against the brasses or work; this is advisable, as the workmen need not be so fussy about the length measurement of the brasses, and also the brass plate from which we cut the liners, shown between brasses, would vary slightly in thickness.

An adjustable swinging arm *G* forms the upper bearing, and is best seen at Fig. 1. This arm swings so as to put work into or take it out of the fixture. The arm is hinged to a screw-adjusted slide, the adjustment of this slide being to accommodate the many different yokes used. The arm is bolted to the slide by a swing bolt. The outer end of the arm is bored to receive a tool-steel spherical-faced plug *H* that enters into a steel plate in the yoke cap. This allows the yoke to be freely revolved after pulling the time pins. The yoke is thus held at four points and is very rigid.

The work is shown in broken lines. A size block *I* is also shown from which the lathe operator sets his tools. This is a quick and very reliable measurement, as the yoke thickness is made to a nicety, the thickness of yoke being 0.001 inch less than the gage or master strap to which the brasses were planed and fitted. The turning of the brasses is done by a tool in the cross slide, while the boring is done with boring bars entering the turret and lathe-spindle bush. Turning and boring are both going on at the same time. The different tools for boring and turning are not shown, being immaterial.

All our yokes were marked for the different engines or jobs, and were kept in a suitable place. A very ordinary workman could turn out a large amount of first-class work with this fixture. This arrangement is quite simple but effective. A number of parts were done in this fixture other than connecting-rod brasses.

Providence, R. I. E. BECK.

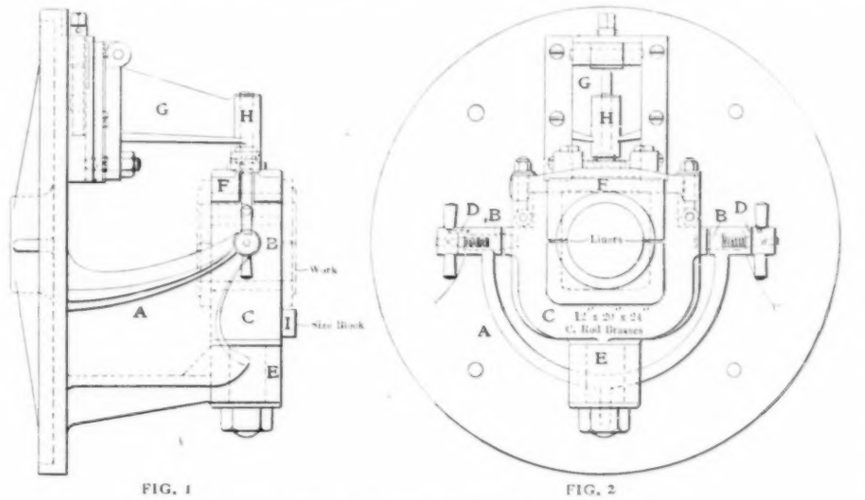


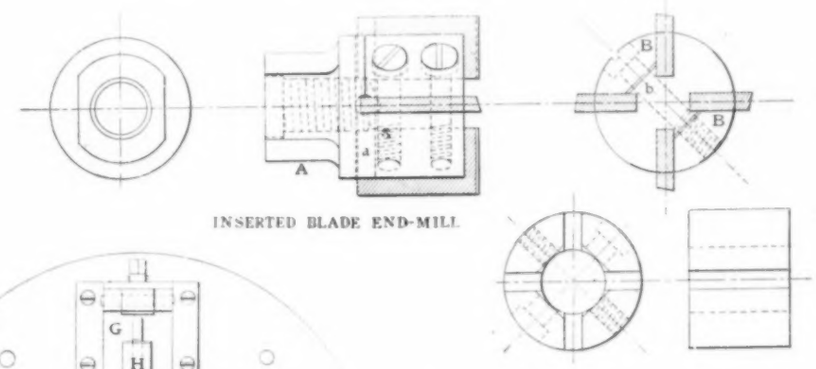
FIG. 1 FIG. 2

FIXTURE FOR BORING CONNECTING-ROD BRASSES

An Inserted Blade End-mill

A number of end-mills were needed by the brass department for use on their nut-facing machines. The kind formerly used were of tool steel, and seemed expensive to make, needing frequent remilling. An inserted-blade cutter was suggested, using high-speed steel, and the sketch shows the design.

The body *A* is of mild steel. The shank bored and threaded right and left, as cutters run together reversed. Holes *a* were drilled clear through the body, and four slots milled to meet them. Two saw cuts were made on two opposite sides, and the stock was cut away with an end mill, leaving space for the clamp pieces *B*. These were drawn together by two ¼-inch 24-thread machine screws serving to securely hold the blades in place.



INSERTED BLADE END-MILL

The pieces *B* were made in the form of rings, drilled for body and head of screw, or for thread. These when parted with ⅛-inch saw each furnished wedges for two cutter heads.

An important feature will be noticed at *b*, where seats are provided, making it necessary that blades be of correct thickness, thereby insuring a uniform clamping effect on all four blades when the two screws are drawn tight.

These mills were a success from the start, and have many times paid for their manufacture. H. E. B.

Camden, N. J.

Red-lead and glycerin when mixed make an excellent material for making tight joints on non-metallic materials.—*Brass World*.

Discussion of the Previous Question

Letters from Our Readers Showing How Many Men of Many Minds Look upon Various Subjects Opened up in Previous Numbers

WE PAY FOR THESE ALSO

The Lining of Bearings

On page 338 of the AMERICAN MACHINIST is an article on the sag in a piano wire when used for lining up bearings. It is stated that it had been used up with success in building several large boats. To my mind the piano-wire method is not the best. It may interest some readers to know what is done in British shipbuilding yards.

The method is what might be called the pin-hole light method. After the bearings and bearing housings have been bored out, the extreme bearing housings and bearings are fixed in the correct positions. In each nose end of all the bearings is clamped a strip of iron, about ⅛ inch thick by 1 inch wide, with a small pin hole drilled in the center. The pin hole in each is fixed exactly central, both horizontally and vertically with the bore of the bearing. When the extreme bearings have been securely fixed the intermediate ones are brought into line. A light, say, a candle, is placed at one end and all the bearings are sighted from the other until a straight line of light can be seen through the lot.

Preston, England. M. PRESTON.

Straightening Tracings

The following method, as shown in sketch, will straighten tracings successfully in a very short period of time.

The drawing table should be covered with clean paper held down by thumb tacks, upon which lay down the tracing with the curled side down and across one end lay a long iron straight-edge, which should project over the sides of the tracing about 2 inches. This straight-edge should weigh about 10 pounds per foot and should be covered with either paper or cloth. Draw the paper through, upward, in the direction shown by arrow once, and then draw it through again, starting with the other end. This will leave the tracing perfectly flat. Two boys can straighten two per minute.

Lowell, Mass. PAUL W. ABBOTT.

Inclosed herewith are two clippings from recent issues of the *Engineering Record* by Jos. F. Storz and T. Peterson respectively. Their methods relate to the flattening of rolled tracings, but should be applicable to those that have only been curled at the edges. I would suggest an electric iron as an alternative to the gas-heated one described by Mr. Peterson, electricity being available in almost every drafting office.

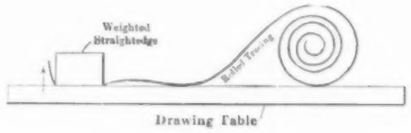
Sherbrooke, Que. S. R. NEWTON.

The question as to how to flatten tracings, so they will lie easily in drawers, is often discussed. Prints give no trouble, as they can be simply immersed in water, and then hung up to dry again. This treatment, of course, is out of the question in regard to tracings.

So I hit upon the following scheme: A small oil heater was secured and lit. The tracings to be flattened were then rolled up in the reverse order of what they had been, and were then held, more or less funnel-shaped over the heater, thus allowing the heat to circulate all over the surface of the map. It was found that upon unrolling, the tracings would lie flat, and gave no more trouble.

Wilkes-Barre, Penn. JAS. F. STORZ.

While in charge of the drafting room



STRAIGHTENING TRACINGS

of the department of water supply, Brooklyn, N. Y., I had to flatten several hundred rolled maps. All of them were unrolled and placed on a table, face down, and kept in that position by weights. Then a hot flatiron was applied to and over the whole surface of each map until the whole stack of maps was gone over, removing each map as soon as the whole surface is gone over with the flatiron. The irons were heated on a small gas stove connected with a jet.

New York. J. PETERSON.

I have been very succesful in straightening tracings by putting them, for a few hours, in a damp place—a basement for instance—then placing them between two flat surfaces, wood or metal, with a few sheets of paper between (newspapers are as good as any) and a weight on them sufficiently heavy to hold them flat. The paper will absorb the moisture and in a short time the tracings will dry and be perfectly straight.

New York. G. M. DIEHL.

How Can Technical-school Shops Do Commercial Work?

This question asked by Professor Gill at page 110 reminds me of that classic rejoinder, to the effect that, the way to resume specie payments is to resume. Just so, the way to do commercial work in a technical-school shop is to do it. Do it right out in the open without any subterfuge, too!

In two ways, however, Professor Gill has wrong impressions. The first is as to what constitutes commercial work. Commercial work is work to be sold to the general public, subjected to comparison with other work of its own class and made to bring the going or market price of the product of shops of purely commercial aim. The other point is in regard to profit from the work of students. My opinion is that if a profit is made it is at the expense of the student, and he is not getting a fair deal. If the discussion was about a trade school I should take the opposite stand but just now I am assuming that the object of every technical school is to turn out engineers, not machinists.

The opposition of outside shops to the sale of work made in technical-school shops is, so far as I could see during 10 year's experience among shops located near such a technical shop, purely an opposition to the sale of product below the market price. Incidentally, the complaint was made that the work could not be good if prices were cut.

I firmly believe that the production of salable work, or the attempt to produce it, would open the eyes of many shop instructors to their own shortcomings. It is very easy to make a thing for one's self that will answer every need, but which will not compare favorably in finished workmanship with the output of machinists. So long as only the parents of students see their work, and so long as the machines they build will "turn over," it appears to be good; but put it out in competition with the world with a name-plate on it, and then watch the columns of advertisements of second-hand machinery three to five years later. They will tell the story. I doubt very much if there is any incentive to good work equal to the desire to make it stay sold after it is made, sold and delivered. If the work is up to a commercially good standard then there is no need for it to be sold under the market price. If the man in charge of such a shop is wise, he will not intentionally al-

low any work to go out that is not a little above the commercial standard. If he does, then no one can complain; for the total amount turned out as salable will be almost nothing, when compared with the total output of any commercial shop with as many men as the school has boys. In my own experience, referred to above, but one manufacturer ever complained of unfair competition. He was more than half socialist to begin with and, to end up with, he never had to go hunting for work. He simply could not have taken on the work that the technical-school shop did.

Why ought not a technical-school shop to pay, and why ought a trade school to pay? Because, if each has 100 pieces of some machine to make a technical school should give out but one piece to a student, unless the student fails to complete his piece in a way which shows that he understood the principles on which he was working. Nine out of ten pieces may not be made so as to pass commercial tests, yet each student may have learned all that he needs to know about making that piece. That is, he knows the principles on which he is working.

On the other hand, the trade school should hand out all these 100 pieces to one boy. It should allow him to spoil two or three, if need be, but it will see to it that he turns in 97 per cent. of the work commercially well done.

Now, why this difference? Because, the boy who wants a trade must do things habitually well; he must do them just so nicely involuntarily. The boy who is to become an engineer must learn to think out each problem for himself, when it is presented. His future ability depends on the capacity for doing something that he has never done before; that may be no one else ever did before.

Why do commercial work in a technical school? Because, the great field now is production engineering; because, ability in production engineering depends on an acquaintance with production at very first hand; because it is impossible to put the same spirit into the study of something hypothetical and far off that can be made to animate something real and necessary.

Fitchburg, Mass. ENTROPY.

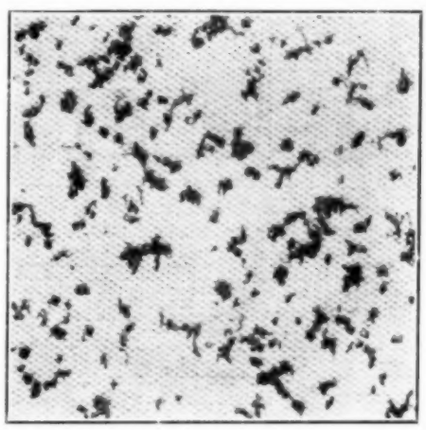
Shop Uses of Plaster of Paris

If I had had that job of the broken gear wheel that Mr. Fick writes about on page 392 I should have drilled one hole in the center of each tooth after filing or chipping the stump somewhat flat, and tapped it to suit a screw and then put a piece of wood on with "Seccotine" (which will stick practically anything to everything) putting the one screw through, and then either shaped it myself or got the patternmaker to do so and I am very sure it would have made a far better job than plaster of paris. Plaster of paris is very good for filling up holes, cracks, or making fillets, but I doubt its practicability on work that has been machined. I find it better to screw a piece of shaped wood on, or drill plain holes the size of wire nails and put the pieces on with them. With all the pattern work I have done, that is, repairs to broken machines when the broken part is used as a pattern, I have found plaster of paris very bad stuff to rely upon in the way Mr. Fick advocates. Where there is only one, or say three castings wanted from a pattern made from a repaired broken part Mr. Fick will find if he tries it, that pieces of a cardboard box or thin pieces of wood stuck on with "Seccotine" is all that is needed without any screws whatever. For large pieces where the part has been machined off or broken off and lost, a piece of wood made to the shape and screwed on will fill the bill cheaply.

Birmingham, Eng. JAS. MACK.

Emery Wheel Chips

I have read with interest C. H. Norton's article in your issue of March 26



EMERY WHEEL CHIPS

on the production of steel "ribbons" on one of his grinding machines. Among those interested in grinding operations, it is generally known that these ribbons were first produced a year and a half ago by J. H. Hollinger on a Landis grinding machine and shown on page 528, Vol. 29, Part 2. It may be interesting to compare the results obtained by him with those now published by Mr. Norton.

Mr. Norton states that the amount of stock removed in his experiments, using the ribbon method, was 0.244 cubic inch per minute, and with a really good Norton wheel 2.34 cubic inches in 1½ minutes, or 1.56 cubic inches per minute. Mr. Hollinger, using the ribbon method removed stock at the rate of 1.75 cubic inches per minute. Mr. Norton states that the poorer the wheel, the better the ribbon. Yet with a wheel so poor that a ribbon was made 0.006 inch thick and 1½ inches wide Mr. Hollinger removed stock 11 per cent. faster than Mr. Norton was able to do with his really good wheel.

Mr. Norton lays great stress on the heating of the work when producing ribbons. All grinding operations produce heat, else a liberal supply of water would not be provided on all up-to-date cylindrical-grinding machines, but in Mr. Hollinger's experiments using a stream of water of the ordinary size, no unusual heating of the work developed, nor was the latter warped or distorted in any way.

In the earlier experiments, an 18x1½-inch corundum wheel was used, and after removing 137 cubic inches of steel the wheel was found to be worn only 3/16 inch in diameter. Mr. Norton, in his estimates of the cost of grinding, does not publish or make any account of the wear of the wheel, but it is safe to say that the wear of his good wheel was far more rapid than the above figure. The fact of the matter is that the conditions under which the work is ground are the determining factors in producing these steel ribbons. If the work is revolved very slowly (1 foot a minute surface speed, or less), the wheel fed in rapidly without traverse, and a wheel of rather hard grade used, these ribbons are certain to be produced. With the same wheel, if the work is speeded up and traversed past the wheel, it is impossible to make ribbons.

Mr. Norton obscures the question when he refers to good and poor wheels. Nearly all abrasive wheels nowadays are made in different grades of hardness to adapt them to different kinds of work. A wheel may be just right for grinding drill blanks, but too hard for finishing reamers. To speak of it as a poor wheel on this account is just as improper as it would be to call a lathe tool poor if, after grinding it to cut cast iron, it was used on tough steel. The best wheel made will produce ribbons if the grade of hardness and conditions of use are right; the poorest wheel in the world will not make them, unless used under the conditions above described.

I do not maintain that stock can be removed faster when the wheel is producing a ribbon than when it is not. The reverse is the case, though the figures given above show that a ribbon-producing wheel will remove stock at a rate in excess of what Mr. Norton cites as the production of one of his really good wheels. With an 18x1½-inch corundum wheel of softer grade, stock was removed from a lot of lathe centers before they were hardened, at the rate of 2¼ cubic inches per minute. Cast iron may, of course, be removed much faster. H. F. Noyes has reported the results of a test in which he removed cast iron with a 19x3-inch corundum wheel at the rate of 5.5 cubic inches per minute.

Mr. Norton evidently wishes it understood that rapid work can only be done

when the particles removed are very small. I inclose illustration (full size) of some steel chips made by the most rapid cutting wheel I have met. These chips are similar to minute lathe chips made with a diamond-pointed tool, and will run from ⅛ to ¼ inch in length. Some are so small in section that they resemble human hairs while others are 0.02 to 0.03 inch in diameter.

To sum up, then, I should say that while the production of ribbons does not indicate the fastest possible removal of stock, yet very good results indeed may be shown when this condition exists, far better in fact than are obtained in 95 per cent. of the places where grinding wheels are used; and that these ribbons *may* be made without excessive heating of the work. H. A. RICHMOND.

Providence, R. I.

Training Married Men

Entropy and others seem to have read into my little protest a meaning that was never intended and I'm explaining in order to save what little hair I've got left in case I ever go to Fitchburg.

I haven't the slightest objection to training men in the shop, married or otherwise, in fact I believe it's the right thing to do, but I do object decidedly to the proposed plan of letting a boy drift from the time he leaves school till he gets married, as must be the result of the universal adoption of Mr. Alvord's idea. As a matter of fact I believe that if Mr. Alvord or Entropy, or any of us, will look back and be honest with ourselves we will not see a very different kind of boy than exists today. The trouble is the tricks that boys play on one another, all of which take time and distract attention from work even if it does no worse, don't seem half as funny to us at 45 as they did at 17; we look at them from a different point of view or try to make ourselves believe we never looked at the clock, always attended strictly to business, and were sorry when the 6 o'clock whistle blew.

A foreman who knows how will get a lot of good work out of the average boy and keep him interested, at the same time he is really learning things that will make him a good mechanic. One trouble is we take a boy at 5 or 6 cents an hour, think of him as a nuisance and treat him as though he was a body servant. Then we advance him a cent or two an hour every six months regardless of his work, just because he is a little older than he was before.

Now a boy is just as interested in finances as his father, and some firms are finding that it pays to start an apprentice at 10 to 12 cents an hour, so that a boy who must support himself can do so and learn the trade at the same time. Usually they make better men than the one who is coddled at home and looked on as a martyr because he "gets up at 6 o'clock and goes to work in a horrid old shop." Make his advancement dependent on his work and his behavior and you'll find that the dollar-a-week raise will be quite an incentive to the boy, especially if he knows that some other fellow didn't get it because of lack of interest or too many pranks.

Some may object that you can't keep boys unless you raise them regardless of their work, but why do you want to keep them if they don't attend to business, and why is this cry about boys not staying with you if they are a general nuisance anyhow? It's a good thing to train all the men in the shop, but don't get the idea that the boy can be neglected, or you won't have men with mechanical ideas enough to make a plumber out of.

Camden, N. J. R. E. MARKS.

Undercutting Tools

At page 293, Raymond Grant describes an undercutting tool for use in the Prentice multiple-spindle automatic screw machine. The tool illustrated will cut the small annular groove very nicely, but is limited to this one form of cut. For the class of work generally encountered, we have for several years been making for our machines a rotary cross-feed tool which cuts internal or external grooves of any desired form. This tool, Fig. 1, is placed in one of the spindles of the machine and operated by an angular wedge and cross-slide mechanism, the wedges being made with the proper angle to give fast or slow cross-slide motion to the cutter head. For external cuts, a ball-bearing pilot receives the thrust of the piece of work as the chuck is fed up to

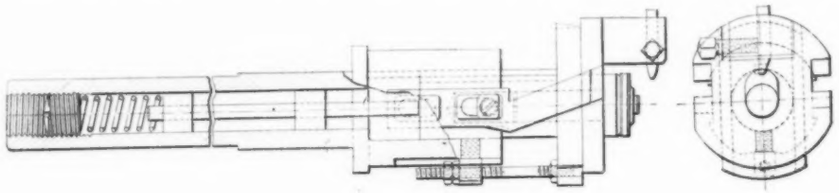
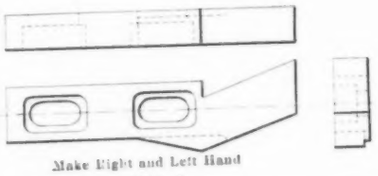


FIG. 1



Make Right and Left Hand

FIG. 2

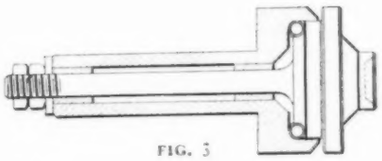


FIG. 3

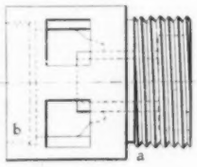


FIG. 4

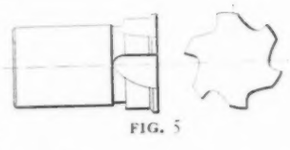


FIG. 5

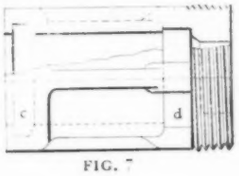


FIG. 7

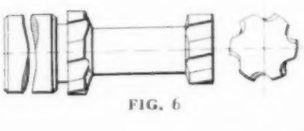


FIG. 6

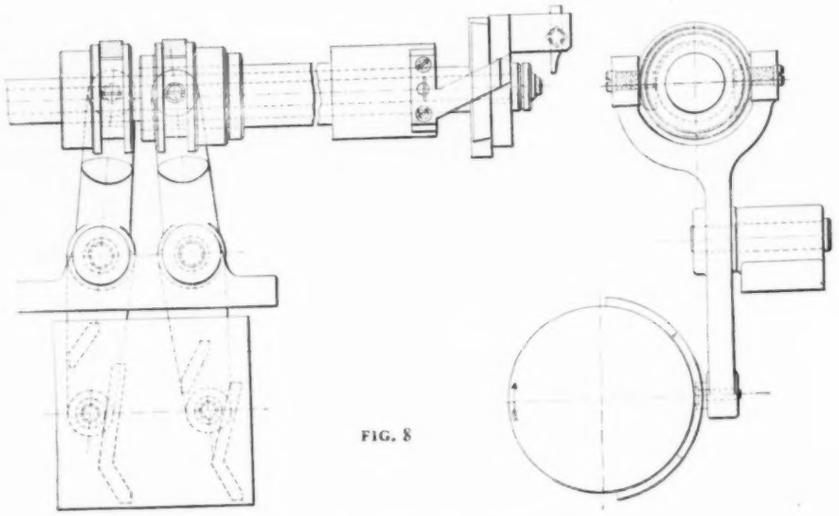


FIG. 8

UNDERCUTTING TOOLS FOR TURRET MACHINE

the tools, and this pressure forces the cutter head back on the wedges and draws the cutter down into the work. When the advance of the work ceases, and the chuck starts to back off, the spring in the hollow spindle forces the cutter head out on the wedges and the tool is drawn out of the work. For cutting internal grooves, the cutter is placed on the opposite side of the head from where placed for external work, and the same taper wedges are used for both forms of cutting.

Fig. 2 shows the shape of the wedges; Fig. 3, the ball-bearing pilot. In Fig. 4, neck *a* is an external cut made with this tool. For internal cutting a circular or single-point tool is mounted on a special head used in place of the cutter head shown in Fig. 1. Fig. 5 is the cutter used for the inside groove *b* in Fig. 4. Fig. 6 is the cutter used for simultaneously forming the two inside grooves *c d* in the work, Fig. 7. On this work the cross motion of the cutter head does not begin until the cutter has entered the work and the face of the work comes in contact with the steel-thrust washer mounted on the cutter head.

There are certain classes of work such as valve, gage and compression-bibb spindles, which are cast with a chucking lug from which the finished piece is severed after all the operations are performed. For this work a rotary cut-off tool is mounted in place of one of the regular spindles of the machine. As the tool must traverse a considerable length over the finished surface of the work to bring the cutting-off tool to the point of operation, the cutter head is fed out by means of the rear lever and cam as shown in Fig. 8. The advance of the chuck brings the work in contact with the ball-bearing pilot in the cutter head and at the same time the forward lever and cam feed the cutter into the work, the feed being accelerated by means of the angle of the cam as the tool enters the work. When the operation is completed a return cam on the forward drum shifts the lever and withdraws the cutter from the work and a similar cam shifts the rear lever and the tool is drawn back ready for the next operation.

The advantage of these cross-feed and cut-off tools as compared with the one illustrated in the article referred to, is that they are constructed on a principle that provides for the cutting of any desired shape of internal or external groove or to completely sever a finished piece of work from its chucking lug.

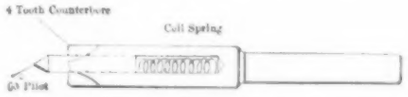
GEO. G. PRENTICE & CO., INC.

New Haven, Conn.

Facing Centered Work

Noticing the discussion in your pages about the facing of work up to the center on the lathe, I beg to submit my method, which is very satisfactory to me, and I consider myself a "crank" on accurate centering.

The sketch needs very little explanation, so I will only add that this method not only allows easy end squaring, but the counterbore prevents damaging center in arbor press, or when arbor is in use.



COUNTERBORE FOR CENTERS

I use three sizes in my work (toolroom) which covers all my ordinary needs; viz., pilots ⅛, 3/16 and ¼ inch, body ¼, ⅜ and ½ inch. R. S.

[This is objected to by some on the ground that the center hole is apt to be damaged by running the tail center into the flat near the hole. It is certainly very convenient for facing the end of the bar. ED.]

The Spiral-fluted Tap

G. Evans Avery, of Tunkhannock, Penn., sends me a spiral-fluted tap, which is shown herewith, that was made 60 or 80 years ago by his grandfather, Cyrus Avery, for tapping gun barrels for the breech pins; which is another evidence that the ancients often stole our inventions.

AN OLD SPIRAL-FLUTED TAP

The only consolation I can get out of it is that Cyrus Avery was my uncle.

Syracuse, N. Y. JOHN E. SWEET.

The Slocomb Micrometer Adjusting Nut

The devices described at page 953, Vol. 30, Part 2, and pages 291 and 401 for recovering the adjusting nuts of Slocomb micrometers from the bottom of the thimbles seem to be over elaborate. No doubt they are effective in operation but they take time to make and such small things if not carefully looked after are often lost. It is not often they are required even in shops where many micrometers are in use and when they are needed it often takes longer to find them than to do the job. A scheme I have never known to fail is the following: Take a piece of paper about 3 inches square and wind it around a lead pencil so that it forms a tube. Hold the paper tube between the first two fingers and thumb and pass it over the spindle until it touches the adjusting nut. A slight downward pressure will cause the teeth on the nut to engage with the end of the paper tube and the nut can then be screwed out by keeping the tube firm and revolving the thimble, taking care to hold the nut and tube in contact.

I have not yet found a nut too tightly pressed to the bottom of the thimble to remove this way.

Coventry, England. B. W.

Grinding Milling Saws

On page 462, Ethan Viall mentions the way some manufacturers grind the sides of their metal-slitting saws, illustrating two methods and stating that in his opinion it is better to grind them with the face of the wheel, while those furnished by some of the leading makers show by the marks left from the wheel in grinding that they were finished with the side of the emery wheel. The method he calls the best was the original way this work was done, but when grinding with the edge of the wheel, if the saw was thin it was springy and tended to yield as it passed the wheel, thus rounding off the cutting edges of the teeth, and making the saw heat and bind when in use.

When grinding with the side of a wheel in a properly constructed machine the pressure of the wheel against the saw is over so large a surface that it tends to keep the saw against the carrier and the teeth are not "dubbed" off on the cutting edge, and it was clearly proved by the oldest manufacturers of saws, who first introduced this kind of grinding, that saws ground in this way were very much superior to the original method.

Fair Haven, Mass. J. O. SURFACE.

Planing to the Arc of a Circle

Referring to the articles at pages 216 and 587 on planing arcs, I wish to state that a method used satisfactorily for several years in a large shop is to use a cast-iron former bar with a slot made to the required arc, in which slot fits a roll mounted on a stud secured to the rear of the tool slide. The former bar is secured to two steel brackets one-half inch thick, which are fastened to the cross-rail. The vertical feed screw is, of course, removed from the head, and tool and slides are guided vertically by the slot in the former bar. To adjust the tool down the rail is lowered in the usual fashion. The former bar may be used either side up according to whether a concave or convex surface is to be planed.

Pittsfield, Mass. S. OLIVER.

Tangs on Twist Drills

On page 296 where your correspondent describes and illustrates the Barth key, he lightly dismisses the statement that "the tang is merely a bluff" because a shop foreman happened to bring forward a drill with a twisted tang at the moment the statement was made.

I hold this coincidence proves nothing, and I should have placed more confidence in your correspondent's views had he fully investigated this matter and told us what caused the tang to twist. I hold it was carelessness on the operator's part and assert that the tang on the end of a twist drill is not absolutely necessary for driving purposes, but is there only to make certain that the taper hole in the spindle will not be destroyed should the taper shank slip. I wish to make my position thoroughly clear as I have had this fact firmly established in my mind by some years' experience with a concern who sell thousands of twist drills annually and who continually have trouble with customers who return drills for replacement, claiming that the tang is too hard or too soft as evidenced by its breaking off or twisting.

I have studied the matter most closely and have not yet failed to demonstrate that the tang gave way, either because the shank was not a good fit in the taper hole in the spindle, or else the operator had been careless in seeing that the shank was firmly forced home to its taper seat. The circumstances may vary a little in each case, but the true reason is stated above. My experience has taught me that almost invariably the tang failed under variations of one or the other following conditions.

The operator has spotted his hole and has withdrawn his spindle and drill to make sure he has centered properly. Sometimes the hole would be drawn, at other times not, but just as the drill was being put back to the work the tang broke, because the shank is not a good fit in the taper hole. Owing to the vibration of the machine, the drill unsupported by work, gets looser and looser on the little hold it may have and when it is suddenly applied to the work, the spiral flutes get hold on the work and as the leverage from the point of the drill to the tang is too great, the tang is broken or twisted.

Or another way, the point of the drill would just be getting through a hole, usually in mild steel plates, and as the end pressure is thus relieved the plate resumes its original position and this little spring up, combined possibly with a drop in the spindle allows the spiral flutes to travel forward in the style of an archimedean drill. Only one thing can thus happen, the taper shank is taken off its seat in the hole and when the drill can travel no further on its spiral flute, the tang is not clear of the slot in the revolving spindle, and being unsupported by the taper shank, the usual result takes place.

Have any of your readers ever seen a tang sheared when the taper shank has been a good fit in its socket? I never have, but should be glad to have some one cite some instances, giving type of machine used, size of drill used, with speed and feed of same. Even if the drill becomes body bound, my experience has been that it threw the belt off.

To press home the fact, I would refer to the practice of such people as the Cincinnati Milling Machine Company. Observe their advertisements from time to time, or secure a copy of their rapid milling book of examples, and then remember that, on the smaller size machines, all the driving is done by the taper shank of the arbor. This carries no tang, but has a draw-back rod which goes right through the spindle. I recently saw a No. 2 plain machine of this make running for some hours carrying seven high-speed cutters, the largest being 6¾ and the smallest 2½ inches, the width of cut equaling 7 inches, the speed about 60 feet per minute periphery and the feed about 3 inches per minute, this without a tang too. ROBT. BROWN.

Scotland.

Drive versus Shrink Fits

G. Schneider on page 398 employed some of his time in showing the advantages of press fits over those made by shrinking. Although in many cases one has its advantages over the other, it appears wrong to me to state that you cannot depend on a shrink fit without testing.

I have seen many so-called shrink fits which could be tapped apart with a hand hammer, but the reason in every case was traceable to the fit part. If the pieces were properly sized I think there will be small room for doubt as to the ultimate strength which it would take to pull them apart.

Mr. Schneider has failed to grasp the fact that the spindles had to be straightened after they were hardened, so as to reduce grinding time, and that no matter whether the pulley was on or off there would be the same number in the scrap heap at the end of the straightening process.

The only use for the holes as far as I ever was able to find out was the ease with which they aided breaking the pulley off the spindle in case the person who had charge of shrinking them on should not get the heat right, and the pulley stuck before it was in place. A wedge hammered into one of the holes causes the pulley to split off easily and quickly and saves the shaft for another.

In conclusion I will say that in my article on the job referred to I merely told how it was done, not how it should be done, or how I would do it, but how I did do it as I was told to by the foreman.

Ottawa, Canada. W. L. MCLAREN.

Injuring Tools in Grinding

On page 793, Vol. 30, Part 2, W. H. Taylor says that fully half the high-speed steel now in use has been more or less injured during the process of grinding. My own experience confirms this statement. A short time ago I was put in to reorganize a section of a manufacturing plant and I began by placing the tool-repairing equipment and grinding store on a good basis. Desiring to be modern I installed a wet-grinding machine built by a prominent house in England and having a wheel ordered specially for the purpose from one of the best U. S. firms.

It had not been in use long before the operators began to shout that their tools did not stand up as well as usual. At first I put this down to prejudice on the part of the operators but as the shout was continued I investigated the matter for myself and my conclusion was that a high-speed wheel was not suitable for high-speed steel, for even with the most careful grinding the edge is affected slightly and the peculiar glazing effect is easily discernable to anyone used to the ordinary type of grindstone. The amount of water thrown on the wheel has been varied from a fine haze to a flood and tools ground after each adjustment have been well tested, the best results being obtained when the largest amount of water was flooded on the tool and the grinders drenched to the skin.

Tools ground on the ordinary grindstone with a reasonable amount of water running on and with the same class of labor stand up to the work much longer than when ground on the high-speed wet grinder under any condition. Some makers of high-speed steel state that water should not touch the tool when being ground as small cracks are likely to develop. My experience does not bear out this instruction. I have never noticed any effect of the kind on the particular brand of steel we use, but I know the effect of grinding dry is to considerably shorten the length of time the tool will keep cutting. I am also strongly of opinion that the effect of dry grinding milling cutters in the universal tool and cutter grinder is bad. I do not think the results obtained from high-speed cutters after being sharpened a few times are anything like as good as they should be or would be if cutting edges could be kept cool when being ground.

Glasgow. J. S. DYSON.

Side Clearance on Circular Tools

A good deal of effort is required to convince most people that what they call side clearance on circular tools is not clearance, but chip pockets. We will take for instance, a cutting-off tool: About twelve years ago we made them like Fig. 1 and I am sorry to say some people make them that way today. It was said to be recessed for side clearance, and to have about ⅛ inch of tool bearing. Most of us know what happened. Tools broke and hand operators fed as slowly and steadily as possible, thinking that they were forcing the tool more than it would stand, while the chips were getting into the recesses and could not get out. The stock make them different. Fig. 3 is more the style used today and they say just about 0.010 clearance on a side; probably they have had a little trouble when they gave them more. This kind of clearance is the point I wish to bring forward. The large chips do not get in, but the small ones do, and the sides of the stock are roughed. It will be more noticeable on the hand machines, as the feed is mostly by hand and more tools are broken there. The automatic has a steady feed and that is what saves the tools generally as there are fewer small chips to get in. Brass is the metal that shows the rough sides, as the chips force through between the tool and stock. I have drawn a circle on Fig. 3 to represent the bar of stock and illustrate the tendency of the stock to make

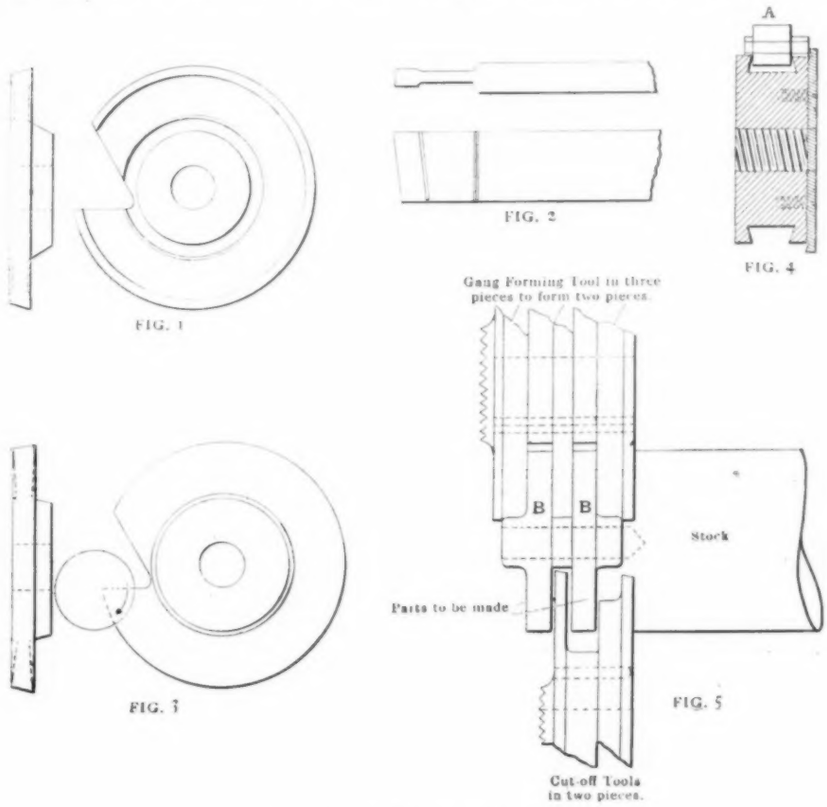


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5

SIDE CLEARANCE ON CIRCULAR TOOLS

revolving on the tool, forced the chips in and also tried to drag them out. But as the ⅛ inch outside diameter was the same width as the groove in the stock, there was no room for the chips to pass out, and when a chip did get dragged out the tool broke. Just imagine a lathe operator using a cutting-off tool like Fig. 2! I don't think he would cut off one piece with it. I often look back to a toolmaker who designed a coaster brake for bicycles and was allowed to make the tools himself. He made a nice set of forming and cut-off tools for the various parts, and everyone of them went to pieces, because he gave them lots of side clearance. I don't think that he did a hundred pieces with them. I heard him remark that if he had to make another set, he would chips and grit follow the direction of the arrow. I claim that the tool should be ground on the sides straight and I have used a great many made 0.0015 inch thicker at the back and got out straighter sides than I have with side clearance. A great deal depends on having the tool set straight or square with the cross slide. I recently got a forming tool, Fig. 4, to use in a hand machine. This tool was designed by the master mechanic who had designed four others and could not get the sides of the piece *A* straight and smooth. He concluded that it required side clearance and lots of it. I told him it would not work, that he had provided chip pockets instead of clearance. Although the work was worse than ever, I could not convince him that a straight tool was required but I got it and soon filled the order.

One other trouble I had was with a gang of tools on an automatic. I had them made straight on the sides like Fig. 5 for making two pieces *B B*. The assistant kept telling me that the stock welded on the sides of the tools and that they ought to have clearance. The operator had the tools out four times in the forenoon and ground about a quarter of an inch off each time. We were using a cheap grade of screw-cutting oil. I had it taken out and good lard oil put in; the tools were sharpened and the machine started again. It was over five days before the tools needed regrinding. The machine ran steadily and there was no welding. After the tools were again sharpened and put back they ran ten days. We took the lard oil out and put back the cheap oil and went right back to welding and grinding in less than one hour. I considered this a good test and have profited by it. I am careful now to blend my own oil and I know what it is composed of.

Stamford, Conn. McK.

Grinding Formed Cutters with Beveled Wheels

I have been greatly interested in the discussion on grinding formed milling cutters. I do not agree with those writers who advocate the use of the beveled side of the emery wheel, because when grinding by this method we are apt to leave a ridge on the wheel which has to be removed when grinding a larger cutter, thereby wasting unnecessary parts of the wheel. Also if not very careful we do not get a straight surface on the face of the tooth.

I have found it preferable when a cutter requires a large amount of stock removing, to sink the cutter downward from the top of the tooth, as by this method you do not heat up the work, also the face of your wheel keeps clean. Then again you save about one-third of the time by this method, which is a great factor where you have to keep a lot of machines going.

In respect to those who advocate using a roughing wheel and another for finishing I do not think this is necessary providing the right grade and grit of emery wheel is used. The best wheel I have tried up to the present is a silicate grade 60, grit J. I quite agree with Mr. Newcomb in his statements respecting greasy work, as a lot of people seem to think that grease does not adhere to the wheel.

Manchester, Eng. NERO.

Hadstock, in Essex, England, derives its entire water supply from a deep well in the parish churchyard known as St. Botolph's well. This is over 800 years old, and is said by its users to contain the best drinking water in England.

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Are We Taking Hold of Industrial Education at the Wrong End?

If there was a note which was sounded louder than any other at the Chicago convention of the National Association for the Promotion of Industrial Education, it was the necessity for giving opportunities which are demanded but not found by the American boy and his parents. One would have thought when listening to the discussions that this boy is clamoring for an opportunity to learn a trade which he cannot find because the apprenticeship system has died out and the shops are closed to the boys who, under present conditions, are found to be unprofitable employees.

It is a serious question if the exact reverse of this is not true, and it is fair to ask if the real demand for these schools does not come from employers, with a large probability of an affirmative answer. The fact seems to be that the shops want apprentices whom they cannot get, and not that the boys want an opportunity to learn a trade, which they cannot find. Employers everywhere tell us that it is almost impossible to get boys, and that the few who are secured remain with them but a short time. It is not even an open secret that the employers who have established schools for apprentices in connection with their shops have, in most instances at least, done so in order to make the shops more attractive to the boys and thus get them and hold them after they are gotten. In some instances these schools have been established in locations where the efficiency of the public schools is very low and the boys are apparently induced to tolerate the shops by the offer of a chance to get what they have been unable to get, or at least have failed to get, in the public schools.

Even Professor Sweet seems to have had a similar experience at his Artisan School of Syracuse. In the recently published report of the committee on education of the Syracuse Chamber of Commerce we find a chapter by him in which, after saying that the only way to get skilful workmen is through schools, he goes on to add: "To say this is easy; to do it is a very different thing. To get the boys is difficult because it is so hard to convince them and their parents that a trade to a boy who must earn his living is as good as five or six thousand in money, and because so few parents are willing to believe their boys are not born to be Presidents of the United States." Again, in the same chapter we find: "The first thing that confronted us and will confront others is to get the money to start with. The next is to get the boys; this, to begin with, means that we must convince them of the value of a trade and that we are going to give them a chance to learn it. Then comes the question of keeping the boys after we have secured them."

Of course, all this in no way militates against the trade-school idea, or against the movement for its development which has obtained such a healthy start. It seems to be a fact, however, that the American boy does not look with longing eyes toward the shop, and that he must be attracted to it, rather than be given an opportunity to enter it. To do the first of these will be an even greater achievement than to do the second, but there is nothing to be gained by looking at the subject from a false view-point. In one sense the situation simplifies the entire problem. If the boys must be coaxed into the schools there is no need of that precipitate haste which now threatens the entire movement. The slower we go the better the ultimate results will be, for, clearly, the establishing of a large number of schools which are to go begging for pupils as soon as they are opened would threaten the entire movement with ridicule and disaster.

From whichever standpoint the matter is viewed, the magnitude of the problem is the same, but if the opening of the schools must be preceded by a preparatory educational process in which the boys and their parents are brought to realize their aims and value, it would clearly be folly to establish the schools in number very much in excess of the demand. In spite of the enthusiasm behind this movement it is quite possible that financial and other difficulties will prevent this, and there is probably no reason for sounding an alarm. There is, however, ample time to go slowly and avoid the ultimate setback which a false start will certainly bring upon the movement.

Bad Packing by American Exporters

The defective packing of American goods sent abroad is one of the chronic subjects of complaint by American consuls as reported in *Daily Consular and Trade Reports.* Among such cases the following are fairly typical. From Alexandria, Egypt, comes the complaint that "shippers and consignees have both been given just cause for complaint owing to the enormous amount of breakage during transshipment. Damage and breakage in a large percentage of cases are directly due to the inadequate methods of packing employed by the shippers. The average American shipper seems to think that all that is necessary is to frame together a few old boards, drive in some big nails—as often as not into the contents—address the consignment illegibly and then turn it over to the transportation company. Goods from European houses, on the other hand, are carefully packed in paper, straw, or excelsior, the cases are strongly

made and bound at the corners with iron bands and plainly marked and stenciled."

From Callao, Peru, comes this complaint: "The most serious obstacle in the pathway of progress is the packing. If manufacturers and merchants could see the havoc wrought in their shipments to South America owing to the careless, indifferent, or ignorant manner in which the packing is done, it would be an object lesson most valuable. 'It is simply sickening,' said an American traveling man to me, whose firm had consigned to him a shipment, one-half of which was ruined by reason of indifferent packing. This is the story all along the line. I am told that in the parcels post department of the post office here American packing is a byword and a joke."

A third complaint comes from Cartagena, Spain, and relates to some locomotives of which the boxed parts were in such flimsy cases that "the scene in the hold of the ship had the appearance of a kindling factory."

It would seem as though American exporters should by this time have learned that sea shipment involves the roughest kind of handling and that they should have adopted adequate packing.

Operating an Old Game

Not long ago we published a communication calling attention to a certain gentleman operating a bunco game in the vicinity of Chicago and Detroit to which several manufacturing concerns became victims. His method was of an old-school type. He would represent himself as being from some not very distant town in want of certain equipment, and after going through the usual procedure of placing an order, he would upon leaving suddenly become aware of the fact that he was a little short of funds for railroad fare and request the loan of a few dollars until he arrived home. That no such party as he represented himself to be ever existed would soon enough transpire, and his railroad fare would have to be charged to "profit and loss."

We are now informed of another slick fellow, or maybe it is the same fellow, of about 30 years of age, 5 feet 8 inches high, slender build, light complexion and crooked teeth, operating another edition of the game, with a special preference to machinery and electrical manufacturing companies. He generally introduces himself as a son or representative of one of a number of important men engaged in the electrical and mechanical field in England, and confirms his identity with a genuine English accent. After finishing his business talk he usually presents some sort of a story about the non-arrival of his weekly remittance, or the fact that he is behind his schedule and his draft is awaiting him at his next stop. Naturally a request for the loan of some money follows in order to carry him over, and needless to say his promise to return it by the first mail is never carried out.

The gentleman in question is reported to be making New York his present field of endeavor, and victims have recently been heard from in Philadelphia, Rochester and other eastern cities.

New Publications

Every man connected with the selling force of a machinery house ought to read the booklet, "What Makes the Best Advertising Medium," by Emerson P. Harris, 253 Broadway, New York. This book goes down into the center of things and is worth the price of 50 cents, but Harris says he will send it free to any reader of this paper who asks for it. We are inclined to think it might be made worth $50 to any concern placing much advertising if the man who places the order read it thoroughly.

CHEMISTRY OF GAS MANUFACTURE. By Harold M. Royle. 316 5⅜x8½-inch pages, 62 illustrations in the text and 20 in the appendices. The Norman W. Henley Publishing Company, New York City, and Crosby Lockwood and Son, London. Price $4.50.

This work is a manual of the chemistry of gas manufacture for the working gas engineer and gasworks manager. It does not go into the operations of manufacture but confines itself to the analysis of the various substances entering into the production of gas and to crude, purified and enriched gases. As it is written from the viewpoint of English practice there are frequent allusions to the requirements, tests, etc., prevailing in England. Appendix A gives the notification of the gas referees of the city of London for the year 1907 in regard to Metropolis gas.

THE ENGINEERING INDEX ANNUAL FOR 1907. 435 6x9-in. pages. The *Engineering Magazine*, New York. Price, $2.

The splendid service of the index department of the *Engineering Magazine* to the engineering profession is well known to everyone. The series of indexes which they have maintained in continuation of the original enterprise by the Association of Engineering Societies, gives a complete index to current engineering literature, in all leading languages from 1884 to date. Six volumes have now been issued, of which the first four cover five years each while the last two are annual, the annual arrangement being a manifest improvement. The appearance of the successive volumes shows that not only is the book of value to engineers, but that it is sufficiently appreciated to make its publication a profitable enterprise. The present volume is upon essentially the same plan as its immediate predecessor, with, however, some improvement in classification and an increased use of cross references.

Personal*

Joseph Campbell, president of the Diamond Saw and Stamping Works, sailed for Europe on the "Carmania," leaving May 2.

W. A. Viall, of the Browne & Sharpe Manufacturing Company, Providence, R. I., sailed recently for a three months' business trip in Europe.

Edward Busby, formerly with the Midvale Steel Company, is at present with the Electric Welding Products Company, this firm having recently changed its name from the Cleveland Cap Screw Company.

W. R. Burrows, formerly with the Norfolk & Southern Railway, has recently been put in charge of the railroad department of Topping Brothers, New York City.

Frank C. B. Page, first vice-president of the E. W. Bliss Company, Brooklyn, N. Y., sailed for Europe on May 2, and expects to spend several weeks abroad in the interests of his company.

H. W. Cheney, until recently engineer-in-charge of electrical detail department of the Bullock branch of the Allis-Chalmers Company at Cincinnati, has been transferred to headquarters at Milwaukee.

Arthur West, chief engineer with the Westinghouse Machine Company, has become manager of power department in charge of manufacturing, engineering, sales, etc., of the Bethlehem Steel Company.

John W. Riley, foreman of the blacksmith shop of the Burlington Route, has accepted a similar position with the Lehigh Valley Railroad at the shops at Sayre, Penn. Mr. Riley succeeds Chas. E. Talada, recently resigned.

Ivar Alfsen, special representative of the American Wood Working Machinery Company, Rochester, N. Y., is making a trip covering the principal countries of Europe. Mr. Alfsen expects to be away for a period of several months.

P. H. Biggs has accepted a position with the Fellows Gear Shaper Company, Springfield, Vt., and will make his headquarters at Detroit. He was formerly connected with the firm of Strong, Carlisle and Hammond, Cleveland, O.

Norman C. Chambers has recently accepted a position as shop engineer with the National Iron and Steel Works, Mexico. The systematizing of shop methods and the introduction of high-speed tools are occupying Mr. Chambers' attention at present.

F. K. Knowlton, president of the Auburn Ball Bearing Company, and of the M. D. Knowlton Company, Rochester, N. Y., recently sailed for Europe on a business trip. His headquarters while abroad will be at their London representatives, Andrew & Sutter, Gosnell road.

*Items for this column are solicited.

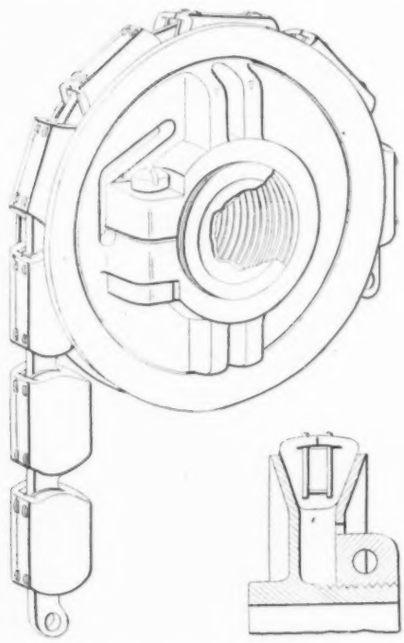
New Tools and Machine Shop Appliances

Showing New Ideas in Machine Shop Equipment That Make It Possible To Do Better Work at a Reduced Cost

THE LATEST INFORMATION

A Chain Belt and Adjustable Pulley

The accompanying line engraving shows a new chain belt and adjustable pulley recently developed by the Whitney Manufacturing Company of Hartford, Conn.



A CHAIN BELT AND ADJUSTABLE PULLEY

The chain is composed of center blocks, rivets and special side links. A piece of leather of special shape is wrapped closely around each pair of side links and is held firmly in place by means of a steel plate on the top surface of the leather. The plate is held in position by projections on the side plates of the chain which pass through the locking plate and are headed over against it. The locking plate has teeth on each side which are imbedded in the leather in order to hold the ends together securely.

Nothing but the leather comes in contact with the grooved pulleys, but the chain center makes the belt absolutely flexible even when running around a pulley of small diameter and prevents the belt from stretching. The drive is noiseless.

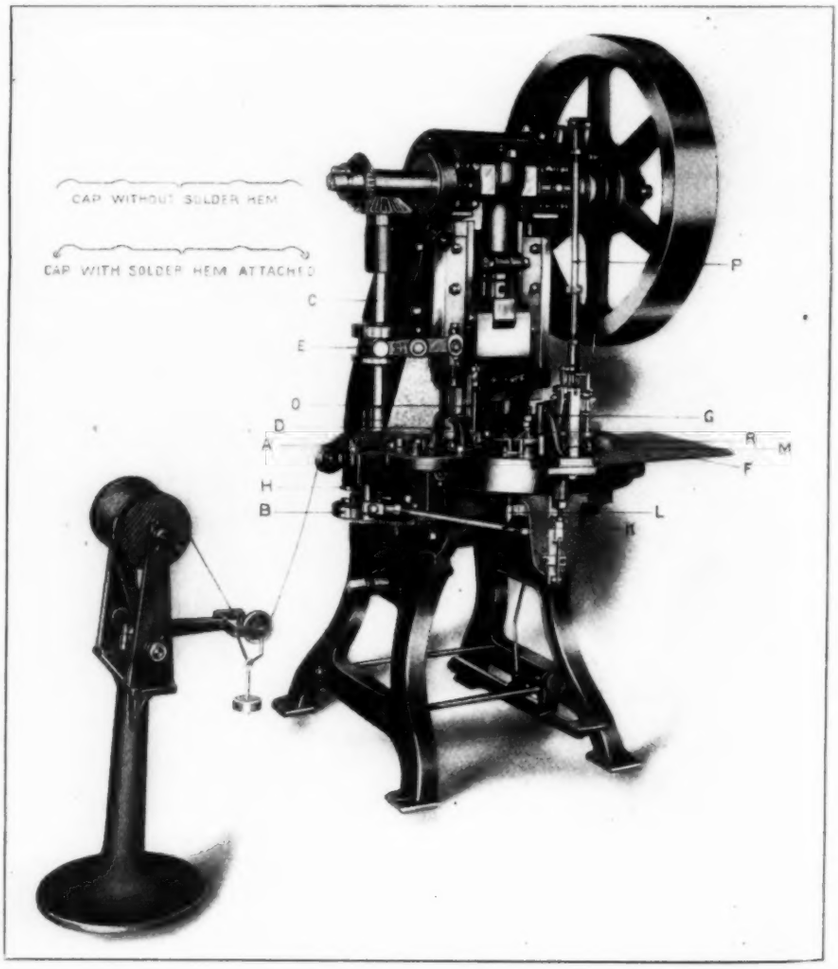
By means of the adjustable pulley the chain belt may be adjusted to the exact tension required without using an idler pulley and without any adjustment between the centers of the pulleys. The flanges of the adjustable pulley are brought together to tighten the chain and when they are separated the chain will loosen.

Solder Cap Hemming Machine

This is an entirely automatic machine for cutting, forming and attaching the solder to caps for fruit cans, as shown, after which the finished cap is positively removed, and all the operator has to do is to place caps in the bushings of the revolving dial plate.

The wire solder is fed from the spool placed on the reel shown at the left-hand side of the press by rolls *A* operated by the Geneva wheel *B*, which is driven by the shaft *C*, operated in turn through the bevel gears on end of crankshaft. The feed rolls *A* are adjustable, so that by a slight turn of a lever the rolls can either be engaged or disengaged. Passing through the feed rolls the wire is fed into the die *D*, which is operated by toggles driven by the face cam *E*. Here the solder is cut off to length, formed into a circle and drops into the dial bushing directly underneath to be carried with the next revolution of the press under the first of two punches carried by the slide. Here it is flattened, passing at the next revolution of the press to the second-operation punch where the forming is done.

Next the blanks, which are fed from the table *F* are dropped into the bushings in which the solder ring is formed, and are carried under a punch operated in the sub-press *G* where the solder is fastened to the caps. This punch is driven by the cam *H* on shaft *C* through toggles and connecting rod *K*. The cap with the



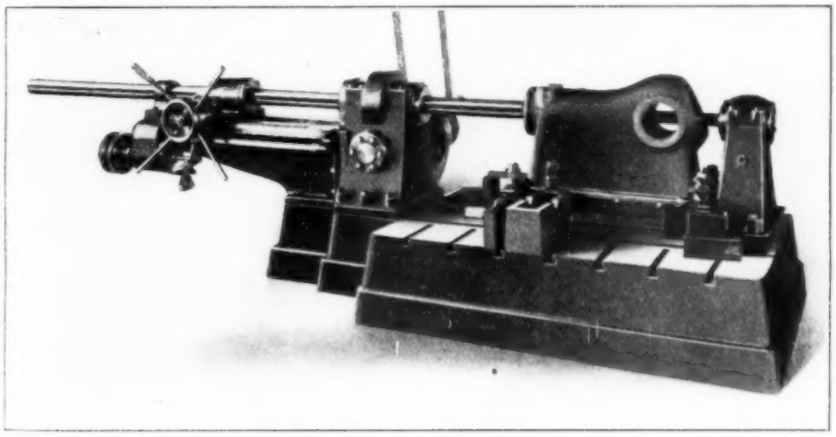
AUTOMATIC SOLDER CAP HEMMING MACHINE

solder attached is raised flush with the top of the bolster by means of the positive knockout *L*. While in this position the positive sweep *M* acts and throws the finished cap into a receptacle conveniently placed to receive it. The return rod *O* insures the return of the pads in the bushings to their proper position before the bushing passes under the die *D*.

To avoid the possibility of feeding two pieces of solder for one cap the press is arranged to stop automatically in the event of the operator failing to place a cap in each bushing, and overcomes the risk of injuring the closing punch. In the event of the dial not registering accurately, this rod *P* not being able to enter the hardened steel bushing *K* in the dial, acts on the clutch and immediately stops the press. The press has a capacity of 75 caps per minute, and weighs 2500 pounds as shown. It is made by the E. W. Bliss Company, Brooklyn, N. Y.

Horizontal Boring Machine

The horizontal boring machine shown in the accompanying illustration is being built by the Patterson Tool and Supply Company, Dayton, Ohio, and as shown is at work on an air-compressor frame. As will be seen, it has a stationary head and the spindle is driven by the worm from the cone pulley at the back. The feed box at the left gives ten changes of feed from 1/64 to 5/32 inch per revolution of the spindle, advancing by 64ths. There is also the usual hand wheel which operates the boring bar.



HORIZONTAL BORING MACHINE

The spindle is 3 inches in diameter by 9 feet long and has a traverse of 22 inches with continuous feed. The distance between the head and outboard bearing is 51 inches, the four-step cone is driven by a 3-inch belt and the ratio of the worm gearing is 25 to 1. Although not shown in this illustration, an attachment can be furnished allowing a cross motion of the boring head so that two cylinder machines can be bored at one setting. The floor space is 40x82 inches, the base is 8½ inches above the floor and the whole machine weighs 4000 pounds.

Double-tang Drill Drive—Erratum

In an article, at page 702, describing this latest development in drill driving, accomplished by the Cleveland Twist Drill Company, the statement that there is no advance in price is a little misleading, as while the list price remains the same as the regular socket, there is a small difference in the discount.

Summer Courses in the University of Wisconsin

Engineering courses, laboratory practice and research work of interest to practicing engineers, contractors and graduates of technical schools will be given in the coming summer session of the University of Wisconsin, beginning June 22 and continuing six weeks.

Among other departments work in the following will be offered:

Mechanical Drawing and Machine Design: Elements of drawing, descriptive geometry, Mechanism, design of machine elements, and complete machines, methods of computation and drafting-room practice.

Mechanics and Testing of Materials: Class work in statics and strength of materials, lectures on the properties of iron, steel, wood, brick, cement and concrete, laboratory tests and research in strength and properties of materials, particular attention being given to plain and reinforced concrete.

Shopwork: Lectures on and practice in pattern making, machine work, forging and treatment of carbon and high-speed steels.

In addition to the above engineering courses, the eighth annual session of the Artisans School will be held during the same period, in which instruction of more elementary type will be given in a large number of subjects, this instruction being adapted to the requirements of students who have common-school training or practical experience.

Bulletins describing the courses of study in detail in both schools may be obtained from F. E. Turneaure, Dean, College of Engineering, Madison, Wis.

Brakes for Quarry Hoisting Engines

By H. L. Bunhus

Sometimes a jobbing machinist gets a job that really requires the services of a mechanical engineer, but there is such good money in it that the machinist will accept it and nearly always makes a success. Here is proof of this statement.

In the mountains of northeastern Pennsylvania are large blue-stone quarries. Nearly all the best ones are located at the top of the highest mountains. The greatest cost in operating these quarries is in getting the stone to the bottom of the mountain to load on railroad cars for shipment. The old way was to build a wagon road that zig-zagged back and forth up the side of the mountain till it reached the quarry, and then bring the stone down on wagons drawn by horses.

At one of these quarries the owners constructed a track straight down the side of the mountain to the railroad switch and ran small flat cars to carry the stone. It was a very easy matter to haul the empty cars up with a cable and hoisting engine, but the question was how to hold the cars back and not let them down too fast. A friction brake was used but the load was so heavy that the friction blocks had to be constantly replaced; besides the brake gave out several times and allowed the loaded cars to run away and do great damage.

Here is where the machinist showed his brains. He was given the job to build a good, reliable brake. After looking the ground over carefully he built a building nearly air tight and without windows. It was 8 feet wide, 12 feet high and 14 feet long. At one side of the hoisting drum, and in this building, he constructed a fan of four blades, each blade six feet wide and five feet long. To the shaft of this fan he connected the hoisting drum with a heavy belt. The friction of the air against this fan would allow it to only make so many revolutions and thus the resistance from this fan held the car back. When the car reached the foot of the incline it was very easy to stop it with the friction brake.

This arrangement gave good results; in fact a car never ran away after this fan was used. In hauling the car back up the

mountain the fan was disconnected from the drum by running the belt on a loose pulley.

Here is another and better way that was used in another quarry. The hoisting drum was connected to a simple air pump or compressor and as the car ran down the hill it operated the air compressor and pumped the air into a large air-tight reservoir. When the car started down it ran quite fast for there was no back pressure in the reservoir, but as the car neared the bottom of the mountain the air pressure in the reservoir would reach 150 to 175 pounds and this pressure would gradually stop the speed of the car. In fact the car would stop or slow down so much that it could be stopped with the hand brake. As soon as the car was unloaded the air compressor would be disconnected from the hoisting drum and a small upright engine connected in. This engine was run with the air that was pumped up when the car went down the hill, and on account of the compressor being larger than the engine and the load heavier going down than coming up, there was enough compressed air in the reservoir to haul back the empty car.

To South America the principal manufactures exported from the United States in the fiscal year 1907 were manufactures of iron and steel, $21,000,000; manufactures of wood, $13,000,000; mineral oil, nearly $8,000,000; agricultural implements, $4,500,000; cars, carriages, etc., $4,000,000; cotton goods, nearly $4,000,000; and chemicals, drugs, dyes, etc., nearly $3,000,000.

Trade in the United States with its American neighbors in 1907 amounted to nearly $1,000,000,000 last year against a little more than a third of a billion a decade ago, as shown by the figures of the Bureau of Statistics, Department of Commerce and Labor.

Mold for Telephone Receiver Caps

By Albert J. Jehl

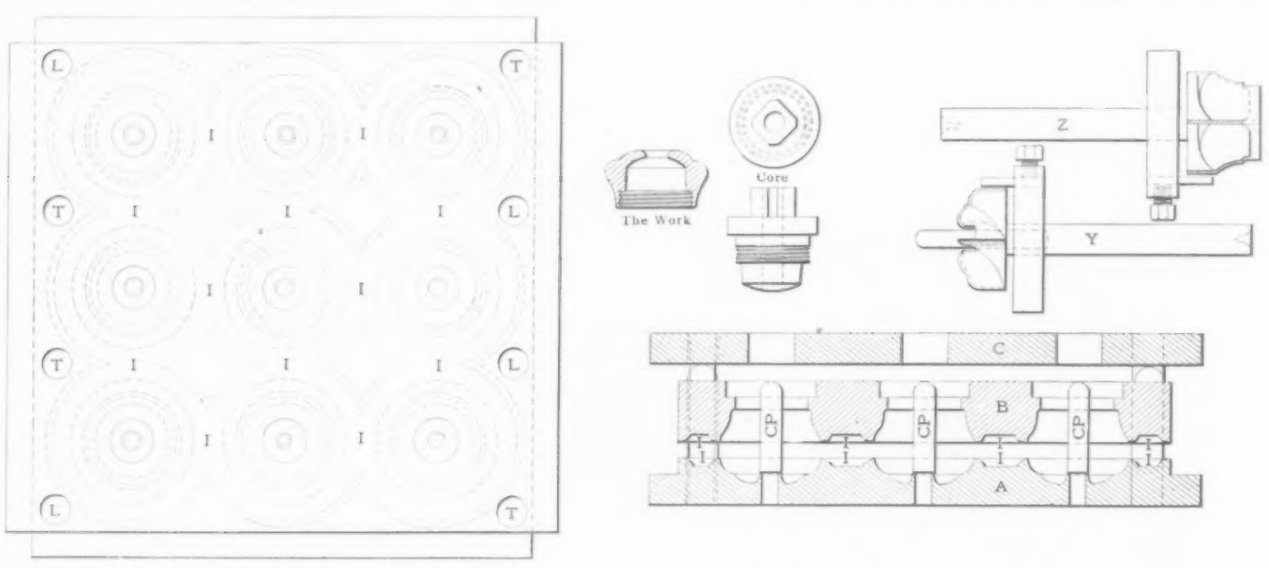
Tools of this kind must be worked up and finished very accurately. Three mild steel plate forgings, absolutely free from flaws or grit are put in the shaper and machined up perfectly true, then the sides and ends finished, leaving them 1 inch longer than they are wide. The finished size in this case is 9x8 inches with the thickness of each being *A* ¼ inch, *B* 1 inch, *C* ½ inch. The pins are laid out on plate *C*, the three plates placed on one another in such a manner as to have the ends of the plate *B* extend beyond both sides of plates *A* and *C* ½ inch, bringing the ends of plates *A* and *C* ½ inch beyond the sides of *B*. The two holes *T T* are finished 1/16 inch smaller than the others. The pins are driven in their respective holes while the plates are together, the plates then separated and all pins fitting too snugly cased up enough to allow them to work easily.

It has been found advisable to make two pins smaller than the rest as it makes is impossible to assemble the parts incorrectly.

The nine impressions are laid out in their proper places on plate *A*, which is strapped on the face-plate of a lathe and trued up to the center of one impression. The straps are placed on the ends of *A* so as to allow *B* and *C* to be placed over it and strapped successively; a hole is drilled through all three plates, small enough to allow all parts to be finished to size. Plate *C* is bored to required dimensions, straps taken off and then removed, giving free access to plate *B* which, after being bored to right size, is removed in like manner. The plate *A* is bored out to fit the cutter Y, which is then inserted, the tailstock center pushed up to it and the cutter sunk to the right depth, a stop on cutter being set to make sure of the impressions not varying. A diamond-point tool which will cut all around is then used to sink the overflow *I* which is run up to within ⅛ inch of the impression and then slightly tapered to its edge, leaving a slight cutting point.

The plate *B* is strapped on the face-plate with the bottom side outward and trued up with one of the holes previously bored, the end of cutter *Z* inserted, which is run in the right depth with stop set as on the other cutter. The overflow is cut in the same manner as the plate *A*. This is repeated for the other eight impressions completing all the cutting on all plates *A*, *B* and *C*.

Cold-rolled steel is cut off long enough and of large enough diameter to make the core pins marked *C P*. The part extending beyond the shoulder is left large enough to drive in the holes in plate *A*. The nine impressions including pins in both plates are then filed with smooth engraver's files to take out all tool and cutter marks, then polished with different grades of emery paper, starting with No. 3 and stopping with No. 00000. A burnishing tool is then used to give a finish that is without a flaw or scratch that can be seen. It has been found best to use emery paper doubled up in small pieces and held in place by a wooden stick. Emery dust or metal laps being almost useless as they have a great tendency to scratch. The cores are of cold-rolled steel cut off the proper length and bored out to size of impression pins in plate *A*, turned to size shown and threaded 0.010 of an inch taper so as to facilitate removal, squared up on top then highly polished and the mold is ready for use.



THE MOLDS FOR MAKING TELEPHONE-RECEIVER CAPS

A hydraulic press is used with the pressure between 3000 and 3500 pounds per square inch and also having the ram and head cored out so as to allow a constant flow of water for cooling purposes, as the material used is worked in a heated state and removed when slightly cooled.

The entire mold, including cores, is separated and placed on steam tables, heated up to a temperature between 280 and 320 degrees Fahrenheit. The heated material consisting of a mixture made to imitate rubber is placed in each impression of plate *A*. Plate *B* is then placed on top, the core is inserted, plate *C* placed over all and the entire mold then put in the press.

The mold is left in the press just long enough to allow the material to harden sufficiently to be handled; the mold is then removed. The mold is placed in a device which holds the upper plate *C* while removing the other two from it. A wrench is placed over the cores giving them a few turns which makes it possible to remove them by hand. The plate *B* is then removed and we have nine caps threaded and finished ready for use. The workman usually has two sets of molds, preparing one for the press while the other is in it cooling off, and can produce between 1000 and 1200 caps daily.

Making Photographic Copies Without a Negative

One of the latest examples of the manner in which photography is being introduced into commercial fields is shown in the Record Outfit, manufactured by the Folmer & Schwing Division of the Eastman Kodak Company, Rochester, N. Y. This outfit was primarily designed for making copies of insurance and real estate documents, but its operation is so simple, inexpensive and effective that it is being rapidly adopted by manufacturing plants for making copies of drawings, illustrations, documents, and in fact, every kind of transcribing.

CAMERA FOR MAKING COPIES WITHOUT A NEGATIVE

The drawing or record to be photographed is placed on a horizontal platform which may be raised or lowered by turning a wheel located at the back of the cabinet. This adjustment regulates the size of the copy. A bromide paper roll holder is attached to the back of the camera and the image projected direct on the paper, a prism reversing the image so that all printed matter reads from left to right in the usual manner. The roll holder is equipped with registering and perforating device, which enables the operator to determine how much paper has been consumed, and also where to cut apart the sheets for developing.

One of the strongest features in favor of the record outfit is its absolute accuracy, every mark appearing on the copy being precisely as it is on the original. Another strong feature is the fact that the drawing, blueprints, etc., may be all copied to standard size for filing and the operation requires but 5 or 6 seconds. The machine does not require the attention of a photographic expert as its operation is extremely simple.

In a large Swiss factory there is employed an automatic machine for threading needles that is reported to have a capacity of 1000 needles per minute, its operation including picking up the needle, propelling it, tying knots, cutting the thread and returning needle to its proper resting place.

A solder for aluminum that has best stood practical tests consists of: Tin, 29 ounces; zinc, 11 ounces; aluminum, 1 ounce; 5 per cent. phosphor tin, 1 ounce. This mixture, according to the *Brass World*, was first made in 1892, and has given satisfaction. It can be applied with the soldering iron or blowpipe.

Business Items

The Goldschmidt Thermit Co., New York has established an office and works at 103 Richmond street, W., Toronto, Canada. E. C. Rutherford, manager.

The Pittsburg (Penn.) Automatic Vise and Tool Company has received an order for vise equipment from the Imperial Steel Works, operated by the Japanese government.

The Electric Controller and Supply Company, of Cleveland, Ohio, has removed its New York office from 120 Liberty street to the Fulton building, Hudson Terminal, 50 Church street.

D. Hurley & Company, 17 Custom House street, Providence, R. I., consulting engineers, has been organized with offices at the above address, and will design and build special machinery and attend to the taking out of patents. D. Hurley, formerly engineer of the Vacuum Cleaner Company, of New York, is the manager.

The Chadbourne-Walker Machine Screw Company, 100 Sudbury street, Boston, Mass., has purchased the plant of the Munroe & Knight Machine Screw Company, and will enlarge the business. They will manufacture all kinds of special machine screws, nuts, bolts, studs, etc., do general machine work and build machines on contract. The officers of the company are George S. Walker, president, and J. E. Chadbourne, treasurer.

Trade Catalogs

Gisholt Machine Company, Madison, Wis. Binder with new bulletins of turret lathes and vertical boring and turning mills. Illustrated.

The Skinner Chuck Company, New Britain, Conn. 1908 catalog and price list of lathe, drill and planer chucks. Illustrated, 40 pages, 4x7 inches, paper.

International Steam Pump Company, 115 Broadway, New York. Bulletin BK-810 describing steam-heating vacuum pumps. Illustrated, 4 pages, 6x9 inches.

Manufacturers

Dahl Brothers, Clifton, Texas, will build cotton gin.

The Knoxville (Tenn.) Iron Company will erect a machine shop.

The Binder Frame Manufacturing Company, Atlanta, Ga., will install additional machinery.

The Broderick & Quinlan Boiler Company, Muncie, Ind., will erect an addition to its plant.

The Kola (Miss.) Lumber Company will rebuild saw mill, dry kiln, etc., recently burned.

A five-story addition will be erected at the plant of the Banner Electric Company, Youngstown, Ohio.

The Michigan Iron and Metal Company, of Grand Rapids, Mich., will establish a plant at Detroit.

Contract has been awarded for a casting, building for the White Eagle Lead Works, Cincinnati, Ohio.

William Davidson Sons, Evansville, Ind., are asking bids for the construction and equipment of a plow factory.

The Johnston Harvester Company Batavia, N. Y., will have a new blacksmith shop erected to replace the present one.

The Grand Trunk Railway will erect car shops at Barre, Ont. W. D. Robb, Montreal, superintendent of motive power.

The United States Steel Corporation will build a plant in the Pittsburg district for the manufacture of steel car wheels.

The Knight-Brinkerhoff Piano Company, Charlotte, Mich., is erecting an addition to its foundry in which iron plates are made.

The National Iron and Steel Works, Apartado 1031, Mexico City, Mex., will increase its shop equipment. N. C. Chambers, shop engineer.

H. J. Miller, of Port Carbon, Penn., is at the head of a syndicate which will establish a textile mill near Pottsville to cost $100,000.

The Bureau of Yards and Docks, Navy Department, Washington, D. C., is having plans prepared for a shop building at Key West.

H. Brewer & Company, Tecumseh, Mich., manufacturing clay-working machinery, will build a new plant to be equipped with modern machinery.

The New York Central & Hudson River Railroad is having plans prepared for addition to roundhouse and other improvements at the yards in Niagara Falls.

The Deason Wrench Manufacturing Company, Poteau, Okla., has been incorporated. Capital $16,000. Incorporators, A. E. Deason, C. D. Hill and C. G. Adkins.

The Gibbs Gas Engine Company, Peters building, Atlanta, Ga., has been organized to manufacture gas engines, etc. C. M. Giddings, Rockford, Ill., engineer in charge.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a. m., June 2, for pumps, power hammer, riddles, molder's brushes, shafting, steel, iron, bolts, rivets, vises, wrenches, etc., as per circular No. 441.

The Sidney (N. Y.) Valve Company, a new concern, has about completed the erection of its foundry and has also leased building for finishing until new one can be erected.

Love Brothers are planning an addition to the plant at Lovedale, a suburb of Aurora, Ill., which will be a foundry and molding department for the manufacture of steel castings.

The Detter Canning and Manufacturing Company, Oklahoma City, Okla., is being organized with $50,000 capital. A canning plant will be erected at once and later on can-making machinery installed. C. E. Detter is manager.

The Nutting-Roe Electric Company, Muncie, Ind., recently incorporated, will establish a plant for the manufacture of electrical equipment. K. E. Nutting and M. L. Roe, directors.

The Crompton & Knowles Loom Works, Worcester, Mass., has awarded contracts for the erection of three additional buildings, which will consist of a machine shop, foundry and factory.

The National Sanitary Company, Salem, Ohio, recently incorporated with $200,000 capital, will erect a plant for the manufacture of bath tubs and other enameled ware. The foundry will have a melting capacity of 35 tons a day.

Want Advertisements

Rate 25 cents a line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Caliper list free. E. G. Smith Co., Columbia, Pa.

If you use small gears in large quantities, write Berry & Parker, Erie, Pa.

Steel case hardened; modern methods. Boston Gear Works, Norfolk Downs, Mass.

We buy or pay royalty for good patented machine or tool. Box 282, AMER. MACHINIST.

Hand power bending tools, labor-saving, money-making. Estep & Dolan, Sandwich, Ill.

Light, fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

Special machinery accurately built. Screw machine and turret lathe work solicited. Robert J. Emory & Co., Newark, N. J.

Automatic machinery designed; special purpose machines; working drawings. C. W. Pitman, 3519 Frankford Ave., Philadelphia.

Shop in Massachusetts well fitted for electrical work desires machinery to build to order or by contract. Box 112, AMERICAN MACHINIST.

We are equipped to turn out twice the number of gears used on our own work, can we do yours to fill in? Samuel M. Langston, Camden, N. J.

Wanted—Shaper about 20" stroke. Vertical power feed to head. Must be in good condition and a bargain. Box 29, AM. MACHINIST.

What am I offered for Volumes 2 to 20 inclusive, AMERICAN MACHINIST; 9 volumes bound; also broken Volumes 21 to 26 inclusive? Box 131, AMERICAN MACHINIST.

Gears cut to order, bevel, spur and miter, on Bilgram and Gleason machines. Complete gears furnished. The Cincinnati Gear Works, Murdock Bldg., Cincinnati, Ohio.

Valuable United States patent for sale outright or on royalty. The latest continuous blueprint machine. B. J. Hall, 41 Castelnau, Barnes, London, England.

Machine screws in small or large quantities direct from factory at low prices. Send particulars of sizes and threads required. Box 97, AMERICAN MACHINIST.

Special machinery and duplicate machine parts built to order; tools, jigs and experimental work; complete modern equipment. MacCordy Mfg. Co., Amsterdam, N. Y.

We wish to place contract for small cast brass cases (3" diameter), similar to steam gauge cases, with firm well equipped to make low price on accurate high grade work. Box 133, AMERICAN MACHINIST.

A large English firm of machine-tool importers having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMERICAN MACHINIST.

Machinists take notice. Purchase castings and blue prints of high grade gasolene motor, of world-wide reputation and at a profitable business. Write today. F. P. Conrad, 242 Freeport St., Harrison Sq., Boston.

British patent rules, 1908. We can produce light, fine engineering and mechanical specialties and tools, accuracy and finish guaranteed. Model Manufacturing Co., 52 Addison Road, North, Holland Park, London.

Machinery built to order and by contract; special parts made; gear cutting, automobile and pattern work, punch press and screw machine work, tools, dies, etc. Blair Tool and Machine Works, West and Morris Sts., New York City.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

Designer or engineer, mechanical five and a half years, technical graduate. Will go anywhere, if permanent. Box 124, AM. MACHINIST.

Tool and die maker, can do own designing and drawing, and can furnish best references as to skill and character, wants position in New England. Box 129, AMERICAN MACHINIST.

ILLINOIS

Experienced mechanical and electrical draftsman wants a position. Box 106, AMERICAN MACHINIST.

Foundry foreman, capable and reliable man. References given. Open shop preferred. Box 122, AMERICAN MACHINIST.

Draftsman with shop experience, technical education and several years at designing tools and machines. Box 138, AMERICAN MACHINIST.

Wanted—Position as draftsman, have had seven years' shop and drawing room experience on paint machinery, automobiles, gearing and special machinery; references. Box 121, AM. M.

MASSACHUSETTS

Experienced designer on automatic and special machinery. First-class references. Box 111, AMERICAN MACHINIST.

Wanted—Position as designing draftsman by a Swedish technical graduate; 27 years of age, with three years' experience in United States. Box 119, AMERICAN MACHINIST.

Position as mechanical engineer or superintendent by a technical graduate; twenty years' experience as draftsman, engineer and superintendent. Box 75, AMERICAN MACHINIST.

NEW YORK

Young man seeks position as draftsman, three years' experience. Box 120, AM. MACH.

Responsible position wanted by practical mechanic. Expert designer of special machinery and tools. Box 107, AMERICAN MACHINIST.

Superintendent, good mechanic and executive, with necessary experience to make your plant pay, desires change. Box 137, AMER. MACH.

Draftsman, fifteen years' experience designing and constructing power houses and industrial plants. Capable superintendent. Box 130, AMERICAN MACHINIST.

Superintendent or manager, twenty years' experience in general foundry and machine business. Engine or like line preferred. Box 109, AMERICAN MACHINIST.

Engineer, German, well educated, with four years' experience in machine tool building for iron and tin industry seeks position. Address A. W., care AMERICAN MACHINIST.

Young German, technical graduate, with large experience in machine tool and electrical field, large steam power plants and repairs seeks suitable position. Address H. J., care AMERICAN MACHINIST.

Young man of ability, age 30, graduate of Worcester Polytechnic Institute, in mechanical engineering, with broad practical experience in mechanical and electrical lines, good executive, will consider executive or engineering position. At present mechanical engineer in large plant. Address Box 123, AMERICAN MACHINIST.

OHIO

Expert cost accountant, young man at present manager of the department of factory organization and costs for a large audit corporation, desires an executive connection with a large manufacturing concern where results are imperative. Box 115, AMERICAN MACHINIST.

PENNSYLVANIA

Engineer, draftsman, mechanical, A-1, experienced. Box 117, AMERICAN MACHINIST.

Practical and experienced draftsman wishes engagement. Apply to Box 136, AMER. MACH.

Automatic screw machine foreman wishes position. Energetic, up-to-date young man. Expert on Brown & Sharpe and Acme machines. Increased production guaranteed. "Temper." AMERICAN MACHINIST.

VIRGINIA

Young man, now general manager $50,000 general machine shop, desires similar position or one as assistant superintendent. Good credit man, practical machinist, technical graduate and can furnish A-1 references. South preferred. Box 113, AMERICAN MACHINIST.

Help Wanted

Classification indicates present address of advertiser, nothing else.

CALIFORNIA

Wanted—Two competent toolsmiths, Navy Yard, Mare Island, Cal. Pay $4.24 per diem. Must be able to dress and temper all classes of tools. Must be citizens. Transportation will not be paid by Government. Apply for information to "Board of Labor Employment, Navy Yard, Mare Island, Cal."

CONNECTICUT

Wanted—First-class draftsman and designer. Capable of taking charge. State experience, age and salary expected. "Capable," AMERICAN MACHINIST.

INDIANA

Wanted—A thoroughly capable working foreman. Must be experienced mechanic on brass work, systematic, good executive ability. We manufacture storm fronts, brass finished, for automobiles. In Chicago; steady position, excellent opportunity for advancement for the proper man. Address with references, stating wages expected. Box 127, AMERICAN MACH.

MASSACHUSETTS

Wanted—Foreman, sub-foreman, assembling and machine hands, experienced in monkey-wrench manufacturing or similar work. Box 128, AMERICAN MACHINIST.

NEW JERSEY

Wanted—In a factory near New York City, practical man to take charge of a plating and polishing department where fine, exacting work is required. Must understand copper and nickel plating, polishing and buffing, and know how to handle help. Good position for right party. Box 126, AMERICAN MACHINIST.

NEW YORK

Wanted—Experienced designer of jigs and fixtures for the manufacture of small interchangeable parts. Box 102, AMER. MACHINIST.

Salesmen and manufacturers' agents wanted in all sections to take as side or additional line a patent article of great merit used in all factories. Address Tostevin & Cottie, 635 Kent Ave., Brooklyn, N. Y.

A typewriter factory needs an energetic, experienced foreman for its milling and drilling department. Applicants must have considerable experience in this line of work and should state age, nationality, salary expected, references and experience in full. Box 132, AMERICAN MACHINIST.

OHIO

Wanted—A-1 practical man to sell machine tools in Central States. Box 134, AM. MACH.

Wanted—Good practical man on presses and forging machinery capable of selling. Territory Central States. Box 135, AMERICAN MACH.

For Sale

For Sale—Whole volumes and back numbers of AMERICAN MACHINIST beginning 1900. Address H. E. Bradley, Apponaug, Rhode Island.

For Sale—Second-hand Hornsby Akroyd oil engines, one 13 horse-power and one 23 horse-power, in first-class shape. Balbach Smelting & Refining Co., Newark, N. J.

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American Emery Wheel Co., Providence, R. I.
Carborundum Co., Niagara Falls, N. Y.
Dickinson, Thos. L., New York.
Norton Co., Worcester, Mass.
Pittsburg Emery Wheel Co., Pittsburg, Pa.
Safety Emery Wheel Co., Springfield, O.
Vitrified Wheel Co., Westfield, Mass.

Agents, Foreign Machinery

Churchill & Co., Chas., London, Eng.
C. I. F. Co., New York.

Air Lifts

Ingersoll-Rand Co., New York.

Alundum

See Grinding Wheels.

Arbor Presses

Barnes Co., W. F. & John, Rockford, Ill.
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Niles-Bement-Pond Co., New York.
Wilmarth & Morman Co., Grand Rapids, Mich.

Arbors

Cleveland Twist Drill Co., Cleveland, O.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
Union Twist Drill Co., Athol, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Balancing Ways

Bowsher Co., N. P., South Bend, Ind.

Barrels, Steel

Lyon Metallic Mfg. Co., Aurora, Ill.

Barrels, Tumbling

Globe Machine & Stamping Co., Cleveland, O.

Bars, Boring

Beaman & Smith Co., Prov., R. I.
Cleveland Twist Drill Co., Cleveland, O.
Elmes Engineering Works, Chas. F., Chicago, Ill.
Krieger Tool & Mfg. Co., Chicago, Ill.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Underwood & Co., H. B., Philadelphia, Pa.

Bearings, Ball and Roller

Boston Gear Works, Norfolk Downs, Mass.
Hyatt Roller Bearing Co., Harrison, N. J.

Belt Dressing

Cling-Surface Mfg. Co., Buffalo, N. Y.
Desmond-Stephan Mfg. Co., Urbana, Ohio.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Belt Fasteners

Bristol Co., Waterbury, Conn

Belt Filler

Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Belt Lacing Machine

Birdsboro Steel Foundry & Mach. Co., Birdsboro, Pa.

Belt Shifters

The L. & D. Co., Boston, Mass.

Belting, Leather

Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Benches, Work

Manufacturing Equipment & Engineering Co., Boston, Mass.

Bending Machinery, Hydraulic

Niles-Bement-Pond Co., New York.
Watson-Stillman Co., New York.

Bending Machinery, Plate

Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.

Bending Machinery, Power

Boynton & Plummer, Worcester, Mass.
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Bending Tools, Hand

Estep & Dolan, Sandwich, Ill.
Wallace Supply Co., Chicago, Ill.

Blocks, Chains

See Hoists, Hand.

Blocks, Die

Nicholson & Co., W. H., Wilkes-Barre, Pa.

Blowers

American Blower Co., Detroit, Mich.
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
General Electric Co., New York.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Roth Brothers & Co., Chicago, Ill.
Sturtevant Co., B. F., Hyde Park, Mass.

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General Electric Co., New York.

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Boynton & Plummer, Worcester, Mass.
Davis Machine Co., W. P., Rochester, N. Y.
Foote-Burt Co., Cleveland, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Landis Machine Co., Waynesboro, Pa.
Manville Mach. Co., E. J., Waterbury, Conn.
McCabe, J. J., New York.
Milton Mfg. Co., Milton, Pa.
Mummert, Wolf & Dixon Co., Hanover, Pa.

Bolt and Nut Machinery —*Continued.*

National-Acme Mfg. Co., Cleveland, O.
National Machinery Co., Tiffin, O.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Northern Electrical Mfg. Co., Madison, Wis.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Engineering Works, Ellwood City, Pa.
Vandyck Churchill Co., New York.
Waterbury Farrel Fdry. & Mach. Co., Waterbury, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Bolt Heads

Lang & Co., G. R., Meadville, Pa.

Bolts and Nuts

Milton Mfg. Co., Milton, Pa.
National-Acme Mfg. Co., Cleveland, O.

Bone for Case Hardening

Rogers & Hubbard Co., Mindletown, Conn.

Books, Technical

American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
Sames, Chas. M., Jersey City, N. J.

Boosters

Burke Electric Co., Erie, Pa.
C & C Electric Co., New York.
Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Roth Bros. & Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Boring and Drilling Machines, Horizontal

Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Betts Mach. Co., Wilmington, Del.
Boynton & Plummer, Worcester, Mass.
Detrick & Harvey Mach. Co., Wilmington, Del.
Fitchburg Machine Works, Fitchburg, Mass.
Fosdick Mach. Tool Co., Cin., O.
Gisholt Mach. Co., Madison, Wis.
Hill, Clarke & Co., Inc., Boston, Mass.
Lucas Mach. Tool Co., Cleveland, O.
McCabe, J. J., New York.
Motch & Merryweather Machinery Co., Cleveland, O.
New Haven Mfg. Co., New Haven, Conn.
Newton Mach. Tool Works, Inc., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Whitcomb-Blaisdell Mach. Tool Co., Worcester, Mass.

Boring and Turning Mills, Vertical

American Tool Works Co., Cin., O.
Baker Bros., Toledo, O.
Baush Mach. Tool Co., Springfield, Mass.

Boring and Turning Mills, Vertical —*Continued.*

Betts Mach. Co., Wilmington, Del.
Bullard Mach. Tool Co., Bridgeport, Conn.
Colburn Mach. Tool Co., Franklin, Pa.
Gisholt Mach. Co., Madison, Wis.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
McCabe, J. J., New York.
Mitts & Merrill, Saginaw, Mich.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Philadelphia, Pa.
Vandyck Churchill Co., New York.

Boring Tools

Armstrong Bros. Tool Co., Chicago, Ill.
Krieger Tool & Mfg. Co., Chicago, Ill.

Boxes, Tote

Lyon Metallic Mfg. Co., Aurora, Ill.

Box Tools, Roughing

Bardons & Oliver, Cleveland, O.

Brazing

Industrial Oxygen Co., New York.

Broaching Machines

Harrington, Son & Co., Edwin, Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Lapointe Mach. Tool Co., Hudson, Mass.

Bulldozers

Bliss Co., E. W., Brooklyn, N. Y.
National Machinery Co., Tiffin, O.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.

Cabinets, Tool

Armstrong Bros. Tool Co., Chicago, Ill.
Hammacher, Schlemmer & Co., New York.
Lyon Metallic Mfg. Co., Aurora, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.

Calipers

Brown & Sharpe Mfg. Co., Providence, R. I.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Slocomb Co., J. T., Providence, R. I.
Starrett Co., L. S., Athol, Mass.

Cams

Bilgram, Hugo, Phila., Pa.
Boston Gear Works, Norfolk Downs, Mass.

Carborundum

See Grinding Wheels.

Carborundum Paper and Cloth

Carborundum Co., Niagara Falls, N. Y.

Case-Hardening

American Gas Furnace Co., New York.
Rogers & Hubbard Co., Middletown, Conn.
Williams & Co., J. H., Brooklyn, N. Y.

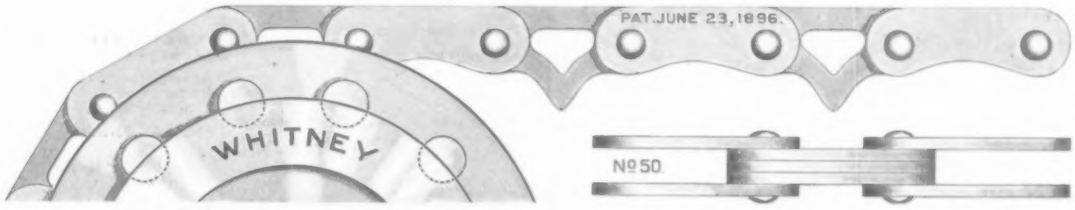
Castings, Brass and Bronze

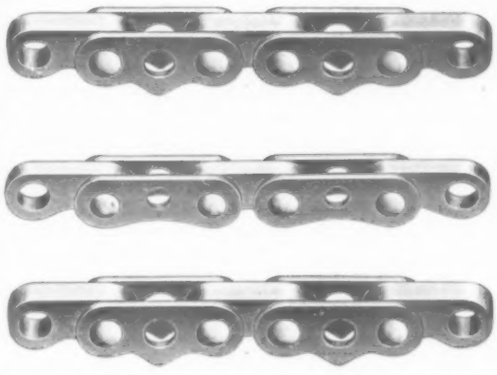
Clum & Atkinson, Rochester, N. Y.
Lumen Bearing Co., Buffalo, N. Y.

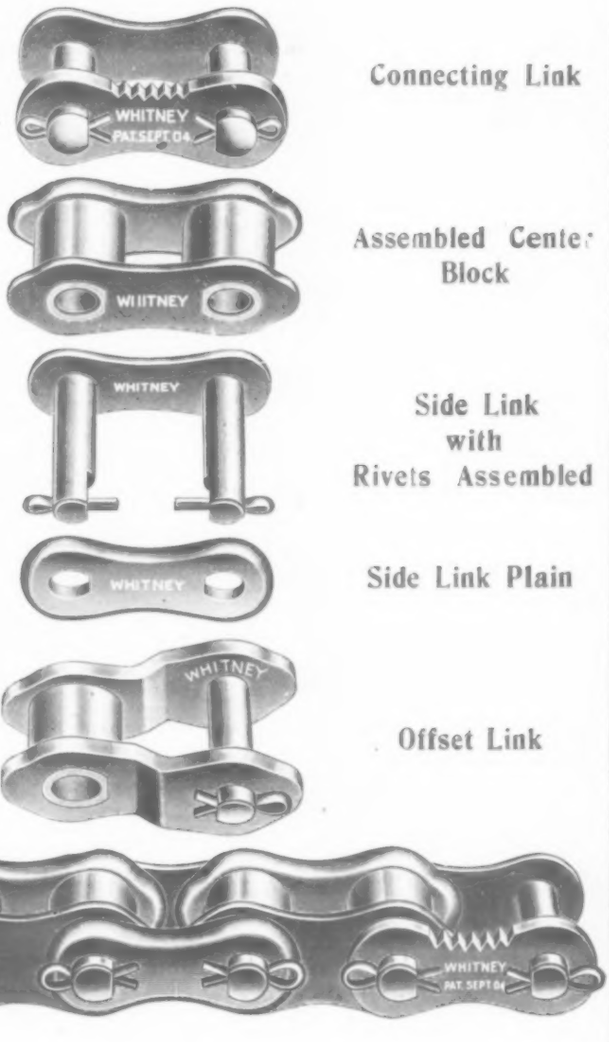
Castings, Die Molded

Berry & Parker, Erie, Pa.
Franklin Mfg. Co., H. H., Syracuse, N. Y.

"Whitney" Chains







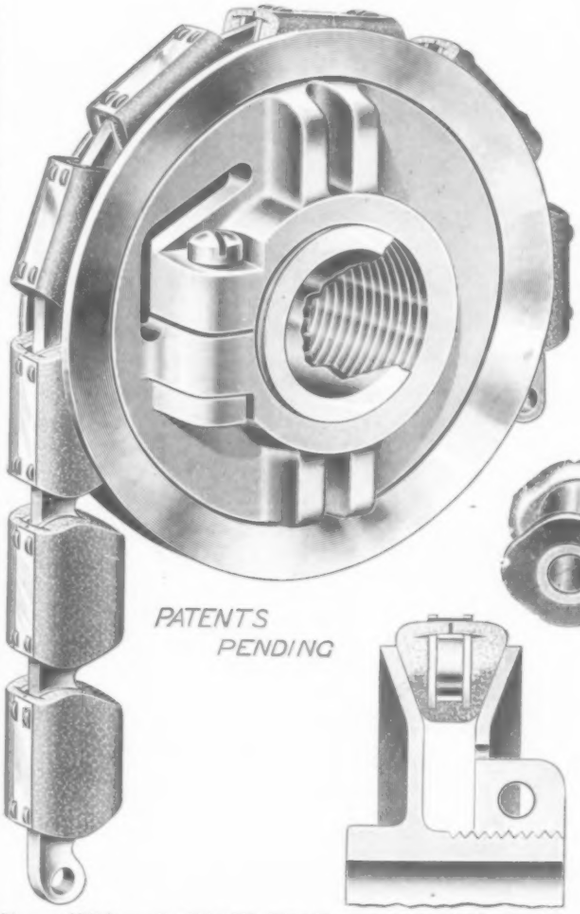
Connecting Link

Assembled Center Block

Side Link with Rivets Assembled

Side Link Plain

Offset Link



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The Whitney Mfg. Co.

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Farrel Fdry. & Mach. Co., Ansonia, Conn.
Taylor & Fenn Co., Hartford, Ct.

Castings, Steel

Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Mass.
Cammel, Laird & Co., New York.

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Clark Cast Steel Cement Co., Shelton, Conn.
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Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Whiton Mach. Co., D. E., New London, Conn.

Centers, Planer

Morse Twist Drill & Mach. Co., New Bedford, Mass.
New Haven Mfg. Co., New Haven, Conn.
Pratt & Whitney Co., Hartford, Conn.
Woodward & Powell Planer Co., Worcester, Mass.

Chains, Driving

Boston Gear Works, Norfolk Downs, Mass.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Link-Belt Co., Philadelphia, Pa.
Morse Chain Co., Ithaca, N. Y.
Whitney Mfg. Co., Hartford, Conn.

Chisels, Cold

Whitman & Barnes Mfg. Co., Chicago, Ill.

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American Tool Wks Co., Cin., O.
Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Automatic Machine Co., Cleveland, O.
Gisholt Mach. Co., Madison, Wis.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
McCabe, J. J., New York.
Reed Co., F. E., Worcester, Mass.
Warner & Swasey Co., Cleveland, Ohio.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.

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Brown & Co., R. H. New Haven, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Cushman Chuck Co., Hartford, Conn.
Grönkvist Drill Chuck Co., Jersey City, N. J.
Horton & Son Co., E., Windsor Locks, Conn.
Jacobs Mfg. Co., Hartford, Conn.
Lancaster Knife and Machine Wks. Lancaster, N. Y.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt Chuck Co., Frankfort, N. Y
Skinner Chuck Co., New Britain, Conn.
Standard Tool Co., Cleveland, O.
Trump Bros. Mach. Co., Wilmington, Del.
Westcott Chuck Co., Oneida, N. Y.
Whitman & Barnes Mfg. Co., Chicago, Ill.
Whitney Mfg. Co., Hartford, Conn
Whiton Mach. Co., D. E., New London, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Chucks, Lathe

Cincinnati Chuck Co., Cincinnati, O.
Cushman Chuck Co., Hartford, Conn.
Gisholt Mach. Co., Madison, Wis.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Horton & Son Co., E., Windsor Locks, Conn.
Niles-Bement-Pond Co., New York.
Pratt Chuck Co., Frankfort, N. Y.

Chucks, Lathe—*Continued.*

Skinner Chuck Co., New Britain, Conn.
Union Mfg. Co., New Britain, Conn.
Westcott Chuck Co., Oneida, N. Y.
Whiton Mach. Co., D. E., New London, Conn.

Chucks, Planer

Harrington & Son Co., Edwin, Philadelphia, Pa.
New Haven Mfg. Co., New Haven, Conn
Niles-Bement-Pond Co., New York.
Skinner Chuck Co., New Britain, Conn.
Westcott Chuck Co., Oneida, N. Y.

Chucks, Split

Hardinge Bros., Chicago, Ill.
Rivett Lathe Mfg. Co., Boston, Mass.
Sloan & Chace Mfg. Co., Ltd., Newark, N. J.
Westcott Chuck Co., Oneida, N. Y.

Circuit Breakers

Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Western Electric Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Clamps

Hammacher, Schlemmer & Co., New York.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Starrett Co., L. S., Athol, Mass.
Tudor Mfg. Co., Taunton, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Clocks, Watchman's

Hardinge Bros., Chicago, Ill.

Clutches, Friction

Bliss Co., E. W., Brooklyn, N. Y.
Caldwell, Son & Co., W. H., Chicago, Ill.
Eastern Machinery Co., New Haven, Conn.
Evans Friction Cone Co., Newton Centre, Mass.
Farrel Fdry. & Mach Co., Ansonia, Conn.
Johnson Mach. Co., Carlyle, Hartford, Conn.
Link-Belt Co., Philadelphia, Pa.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Williams Foundry & Machine Co., Akron, Ohio.

Coal Handling Machinery

Link-Belt Co., Philadelphia, Pa.

Compound, Core

Obermayer Co., S., Cincinnati, O.

Compound, Pipe Joint

Dixon Crucible Co., Joseph, Jersey City, N. J.

Compressors, Air

Blaisdell Machinery Co., Bradford, Pa.
Blanchard Machine Co., Cambridge, Mass.
Bury Compressor Co., Erie, Pa.
Clayton Air Compressor Works, New York.
Independent Pneumatic Tool Co., Chicago, Ill.
Ingersoll-Rand Co., New York.
Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.
Spacke Machine Co., F. W., Indianapolis, Ind.

Compressors, Gas

Blaisdell Machinery Co., Bradford, Pa.
Ingersoll-Rand Co., New York.

Cones, Friction

Evans Friction Cone Co., Newton Centre, Mass.

Connecting Rods and Straps

Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Contract Work

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Cell Drier Mach. Co., Taunton, Mass.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Ingle Machine Co., Rocester, N. Y.
Manville Bros. Co., Waterbury, Conn.
Merritt, Jos., Hartford, Conn.
Turner Mach. Co., Danbury, Conn.

Controllers and Starters, Electric Motor

Crocker-Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Conveyors, Automatic

Lamson Consolidated Store Service Co., Boston, Mass.
Link-Belt Co., Philadelphia, Pa.

Coping Machines

Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York

Corundum

See Grinding Wheels.

Cotters

Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Standard Tool Co., Cleveland, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Counterbores

Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Slocomb Co., J. T., Prov., R. I.
Starrett Co., L. S., Athol, Mass.

Counters, Revolution

Root Co., C. J., Bristol, Conn.
Schuchardt & Schutte, New York.
Veeder Mfg. Co., Hartford, Conn.

Countershafts

Almond Mfg. Co., T. R., Brooklyn, N. Y.
Builders Iron Foundry, Providence, R. I.
Coates Clipper Mfg. Co., Worcester, Mass
Evans Friction Cone Co., Newton Centre, Mass.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
McCabe, J. J., New York.
Mossberg Wrench Co., Central Falls, R. I.
Norton Grinding Co., Worcester, Mass.
Safety Emery Wheel Co., Springfield, Ohio
Smith Countershaft Co., Boston, Mass.

Countershafts, Friction

Evans Friction Cone Co., Newton Centre, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Countershafts, Speed Changing

Evans Friction Cone Co., Newton Centre, Mass.
Gisholt Mach. Co., Madison, Wis.

Counting and Printing Wheels

Franklin Mfg. Co., H. H., Syracuse, N. Y.

Couplers, Hose

Independent Pneu. Tool Co., Chicago, Ill.
Ingersoll-Rand Co., New York.

Couplings

Almond Mfg. Co., T. R., Brooklyn, N. Y.
Caldwell & Son Co., H. W., Chicago, Ill.
Davis Machine Co., W. P., Rochester, N. Y.
Link-Belt Co., Philadelphia, Pa.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Gauge Steel Co., Beaver Falls, Pa.
Williams Fdry. & Mach. Co., Akron, Ohio.

Cranes

Brown Hoisting Mach. Co., Cleveland, O.
Case Mfg. Co., Columbus, O.
Cleveland Crane & Car Co., Wickliffe, O.
Crescent Forgings Co., Oakmont, Pa.
Franklin Port. Crane and Hoist Co., Franklin, Pa.
Manning, Maxwell & Moore, Inc., New York.
Maris Bros., Philadelphia, Pa

Cranes—*Continued.*

Moore Co., Franklin, Winsted, Ct.
Nicholls, Wm. S., New York.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.
Obermayer Co., S., Cincinnati, O.
Pawling & Harnischfeger, Milwaukee, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.
Vandyck Churchill Co., New York.
Yale & Towne Mfg. Co., New York.

Crank Pin Turning Machines

Niles-Bement-Pond Co., New York.
Underwood & Co., H. B., Philadelphia, Pa.

Crank Shafts

Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Crucibles

Dixon Crucible Co., Joseph, Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Crushers

Farrel Fdry. & Mach. Co., Ansonia, Conn.
Niles-Bement-Pond Co., New York.
Link-Belt Co., Philadelphia, Pa.

Cupolas and Ladles, Foundry

Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.

Cups, Grease

Lunkenheimer Co., Cincinnati, O.

Cutters, Milling

Adams Co., Dubuque, Iowa.
Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Hardinge Bros., Chicago, Ill.
Harrison & Knight Mfg. Co., Newark, N. J.
Ingersoll Milling Mach. Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Sloan & Chace Mfg. Co., Ltd., Newark, N. J.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Ward & Son, Edgar T., Boston, Mass.
Whitney Mfg. Co., Hartford, Ct.

Cutting-off Machines

Armstrong Bros. Tool Co., Chicago, Ill.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Brown & Sharpe Mfg. Co., Providence, R. I.
Davis Machine Co., W. P., Rochester, N. Y.
Hurlburt-Rogers Mach. Co., South Sudbury, Mass.
McCabe, J. J., New York.
Newton Mach. Tool Wks., Inc., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Schmitz, August, Dusseldorf, Germany.
Tindel-Morris Co., Eddystone, Pa.
Vandyck Churchill Co., New York.

Cutting-off Tools

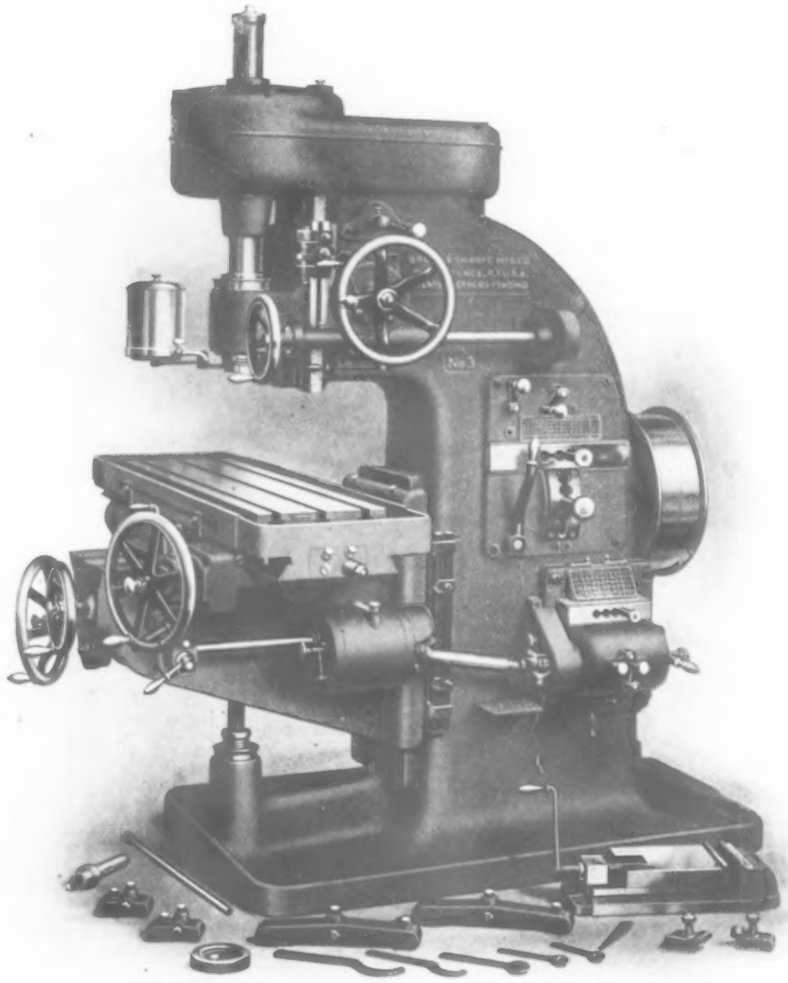
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Fitchburg Machine Works, Fitchburg, Mass.
Krieger Tool & Mfg. Co., Chicago, Ill.
O. K. Tool Holder Co., Shelton, Conn.
Pratt & Whitney Co., Hartford, Conn.

Diamond Tools

American Emery Wheel Co., Providence, R. I.
Dickinson, Thos. L., New York.
Safety Emery Wheel Co., Springfield, O.

BROWN & SHARPE MFG. CO.

PROVIDENCE, R. I., U. S. A.



No. 3 VERTICAL SPINDLE MILLING MACHINE.

Capacity: Longitudinal Feed, 34"; Transverse feed, 13½".
Greatest distance end of spindle to top of table, 23".

If you will take into consideration the vast amount of work you are doing on a horizontal spindle milling machine by the aid of expensive jigs and fixtures, you will see at once the need of a vertical spindle milling machine. With this type of a machine, such work as profiling and cutting of slots, face milling and the milling of angular ways and straight surfaces, can be rigidly bolted to the table and the operation performed in full sight of the operator.

Special circular, describing this machine, sent to any address.

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Bliss Co., E. W., Brooklyn, N. Y.
Consolidated Press and Tool Co., Hastings, Mich.
Ferracute Mach. Co., Bridgeton, N. J.
Globe Machine & Stamping Co., Cleveland, O.
Manville Bros. Co., Waterbury, Conn.

Dies, Sub-Press

Sloan & Chace Mfg. Co., Newark, N. J.
Waltham Machine Works, Waltham, Mass.

Dies, Threading, Opening

Allen Co., Chas. G., Barre, Mass.
Errington, F. A., New York.
Foote-Burt Co., Cleveland, O.
Geometric Tool Co., New Haven, Conn.
Jones & Lamson Machine Co., Springfield, Vt.
Pratt & Whitney Co., Hartford, Conn.

Drawing Boards and Tables

Alteneder & Son, Theo., Philadelphia, Pa.

Kolesch & Co., New York

Drawing Materials

Alteneder & Son, Theo., Philadelphia, Pa.
Kolesch & Co., New York.
Technical Supply Co., Scranton, Pa.

Drafting Machines

Universal Drafting Mach. Co., Cleveland, O.

Drilling Machines, Bench

American Watch Tool Co., Waltham, Mass.
Barnes Co., W. F. & John, Rockford, Ill.
Boynton & Plummer, Worcester, Mass.
Ingersoll-Rand Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentice Bros. Co., Worcester, Mass.
Rockford Drilling Mach. Co., Rockford, Ill.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Ltd., Newark, N. J.
U. S. Electrical Tool Co., Cincinnati, O.

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Boynton & Plummer, Worcester, Mass.
Foote-Burt Co., The, Cleveland, O.
Ingersoll-Rand Co., New York.
McCabe, J. J., New York.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Multiple Spindle

Allen Co., Chas. G., Barre, Mass.
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, Rockford, Ill.
Baush Mach. Tool Co., Springfield, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Flather Planer Co., Mark, Nashua, N. H.
Foote-Burt Co., The, Cleveland, Ohio.
Fosdick Mach. Tool Co., Cin., O.
Hardinge Bros., Chicago, Ill.
Harrington Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Newton Mach. Tool Works, Inc., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Slate Machine Co., Dwight, Hartford, Conn.
Taylor & Fenn Co., Hartford, Conn.

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Cincinnati Elec. Tool Co., Cin., O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Gem Mfg. Co., Pittsburg, Pa.
Hisey-Wolf Mach. Co., Cin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drilling Machines, Radial

American Tool Works Co., Cin., O.
Baush Mach. Tool Co., Springfield, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Dreses Mach. Tool Co., Cin., O.
Fitchburg Machine Works, Fitchburg, Mass.
Foote-Burt Co., Cleveland, O.
Fosdick Mach. Tool Co., Cin., O.
Gang Co., Wm. E., Cincinnati, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morris Foundry Co., Jno. B., Cincinnati, O.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Wormer Mchy. Co., C. C., Detroit, Mich.

Drilling Machines, Turret

Fay Machine Tool Co., Phila., Pa.
Niles-Bement-Pond Co., New York.

Drilling Machines, Upright

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American Tool Works Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Boynton & Plummer, Worcester, Mass.
Cincinnati Mach. Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.
Davis Machine Co., W. P., Rochester, N. Y.
Fosdick Mach. Co., Tool Co., Cin., O.
Foote-Burt Co., Cleveland, O.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Hoefer Mfg. Co., Freeport, Ill.
Kern Mach. Tool Co., Cincinnati, O.
Knight Machry. Co., W. B., St. Louis, Mo.
Marshall & Huschart Machry. Co., Chicago, Ill.
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Mechanics Machine Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Sibley Machine Tool Co., South Bend, Ind.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Taylor & Fenn Co., Hartford, Conn.
Vandyck Churchill Co., New York.
Whitney Mfg. Co., Hartford, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.
Worner Mchry. Co., C. C., Detroit, Mich.

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Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Slocomb Co., J. T., Prov., R. I.
Standard Tool Co., Cleveland, O.

Drills, Electric

Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.
Independent Pneumatic Tool Co., Chicago, Ill.
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Whitman & Barnes Mfg. Co., Chicago, Ill.

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Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

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Clayton Air Compressor Works, New York.
Independent Pneumatic Tool Co., Chicago, Ill.
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Foote-Burt Co., Cleveland, O.
General Pneumatic Tool Co., Montour Falls, N. Y.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Standard Tool Co., Cleveland, O.

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Armstrong Bros. Tool Co., Chicago, Ill.
Cleveland Twist Drill Co., Cleveland, O.
Hisey-Wolf Mach. Co., Cin., O.
Parker Co., Chas., Meriden, Conn.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, John M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.

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Drill Speeder

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Crocker-Wheeler Co., Ampere, N. J.
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Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
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Roth Bros. & Co., Chicago, Ill.
Sturtevant Co., B. F., Hyde Park, Mass.
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Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

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Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
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General Electric Co., New York.
Jantz & Leist Elec. Co., Cincinnati, O.
Northern Elec. Mfg. Co., Madison, Wis.
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Triumph Electric Co., Cincinnati, O.
Wagner Elec. Mfg. Co., St. Louis, Mo.
Western Electric Co., Chicago, Ill.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

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Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Crescent Forgings Co., Oakmont, Pa.
Hisey-Wolf Mach. Co., Cincin., O.
Roth Bros. & Co., Chicago, Ill.
U. S. Electrical Tool Co., Cincinnati, O.

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See Grinding Wheels,

Emery Wheel Dressers

American Emery Wheel Co., Providence, R. I.
Desmond-Stephan Mfg. Co., Urbana, O.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Dickinson, Thos. L., New York.
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Vitrified Wheel Co., Westfield, Mass.
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Hart & Cooley Co., New Britain, Conn.

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Ridgway Dynamo & Engine Co., Ridgway, Pa.

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Philadelphia Bourse, Phila., Pa.

Expanders, Tube

Nicholson & Co., W. H., Wilkes Barre, Pa.

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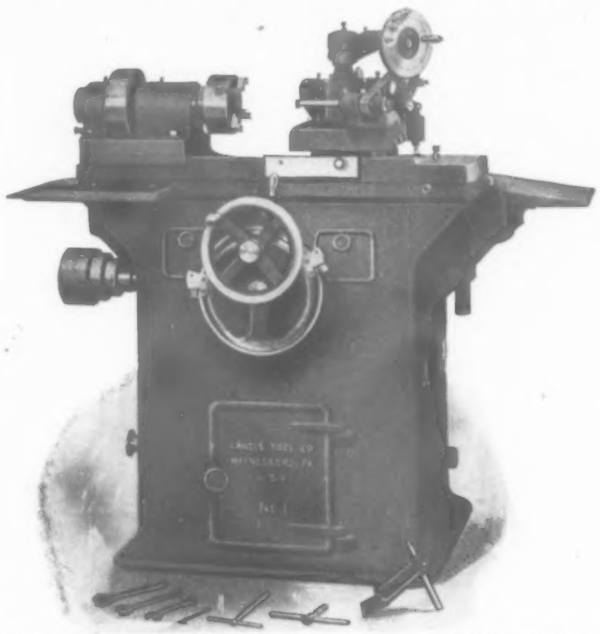

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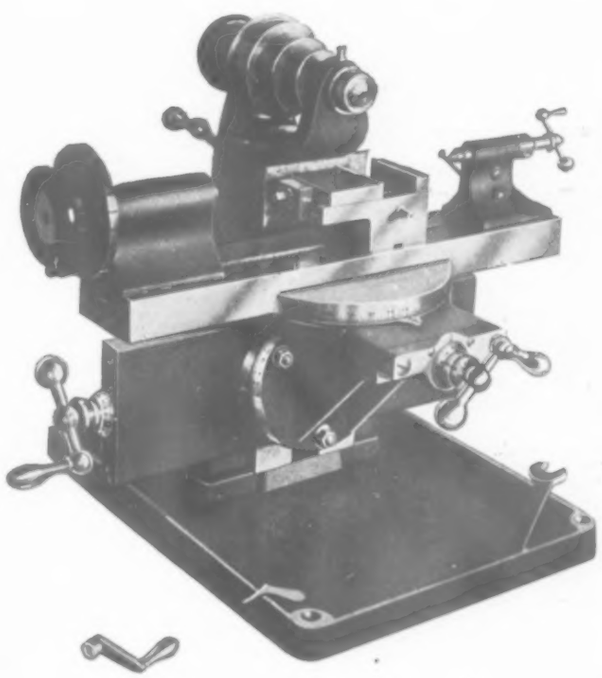

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Cincinnat Shaper Co., Cincinnati, Ohio.
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Waltham Machine Works, Waltham, Mass.
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Bilgram, Hugo, Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
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Chicago Raw Hide Mfg. Co., Chicago, Ill.
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Farrel Fdry. & Mach. Co., Ansonia, Conn.
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Gould & Eberhardt, Newark, N. J.
Grant Gear Works, Boston, Mass.
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Lea Equipment Co., New York.
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Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
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Gould & Eberhardt, Newark, N. J.
Grant Gear Works, Boston, Mass.
Horsburgh & Scott Co., Cleveland, O.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Works, Cleveland, O.
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Albro-Clem Elevator Co., Philadelphia, Pa.
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Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Horsburgh & Scott Co., Cleveland, O.
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Triumph Elec. Co., Cincinnati, O.

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Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
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Gould & Eberhardt, Newark, N. J.
Heald Mach. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
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McCabe, J. J., New York.
Niles-Bement-Pond Co., New York.
Norton Grinding Co., Worcester, Mass.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Rivett Lathe Mfg. Co., Boston, Mass.
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Landis Toool Co., Waynesboro, Pa.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Norton Grinding Co., Worcester, Mass.

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Bath Grinder Co., Inc., Fitchburg, Mass.
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Taylor & Fenn Co., Hartford, Conn.

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Niles-Bement-Pond Co., New York.
Safety Emery Wheel Co., Springfield, Ohio.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Tool Co., Cleveland, O.
U. S. Electrical Tool Co., Cincinnati, Ohio.
Wilmarth & Mormon Co., Grand Rapids, Mich.

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Bath Grinder Co., Inc., Fitchburg, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Heald Mach. Co., Worcester, Mass.
Landis Tool Co., Waynesboro, Pa.
Rivett Lathe Mfg. Co., Boston, Mass.
U. S. Electrical Tool Co., Cincinnati, O.

Grinders, Knife
American Wood Working Mchy Co., Rochester, N. Y.
Safety Emery Wheel Co., Springfield, O.

Grinders, Portable
Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincinnati, O.
U. S. Electrical Co., Cincinnati, Ohio.

Grinders, Saw
Tindel-Morris Co., Eddystone, Pa.

Grinders, Tool
Armstrong Bros. Tool Co., Chicago, Ill.
Barnes Co., W. F. & John, Rockford, Ill.
Bath Grinder Co., Inc., Fitchburg, Mass.
Blount Co., J. G., Everett, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Electrical Tool Co., Cincinnati, O.
Cincinnati Milling Machine Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Diamond Machine Co., Providence, R. I.
Gisholt Mach. Co., Madison, Wis.
Gould & Eberhardt, Newark, N. J.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Harrington, Son & Co., Edwin, Philadelphia, Pa
Heald Mach. Co., Worcester, Mass.
Hisey-Wolf Mach Co., Cincin., O.
Landis Tool Co., Waynesboro, Pa.
McCabe, J. J., New York.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Mummert, Wolf & Dixon Co., Hanover, Pa.
Niles-Bement-Pond Co., New York.
Norton Grinding Co., Worcester, Mass.
Rivett Lathe Mfg Co., Boston, Mass.
Rockford Drilling Mach. Co., Rockford, Ill.
Safety Emery Wheel Co., Springfield, O.
Sellers & Co., Inc. Wm., Philadelphia, Pa.
Standard Tool Co., Cleveland, O.
U. S. Electrical Tool Co., Cincinnati, O.
Vandyck Churchill Co., New York.
Vitrified Wheel Co., Westfield, Mass
Whitney Mfg. Co., Hartford, Conn.